Instruction MANUAL

SERIES 50A FUNCTION GENERATOR

MODEL F51A

A Subsidiary Of A-T-O Inc.

INTERSTATE ELECTRONICS CORPORATION

Department 7000 707 EAST VERMONT AVENUE, ANAHEIM, CALIFORNIA 92803 • (714) 772-2811

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REV. A

WARRANTY

Interstate Electronics Corporation warrants its function generators against defects in material and workmanship for a period of one year from date of shipment. We will repair or replace defective products during the warranty period provided that such defect developed under normal and proper use and that transportation costs are paid by the purchaser. We are not liable for consequential damages nor is any other warranty expressed or implied.

F51A ERRATA SHEET

(For F51A serial #1644 and all subsequent serial numbers.)

Correct the pages indicated below as follows:

Page			
6-11	Change R20 to 150 ohms R: Metal Glaze 1/4 W ±5%	75042	RG1/4-151-J
	Change R24 to 150 ohms R: Metal Glaze 1/4 W ±5%	75042	RG1/4-151-J
	Change R43-R44 to 464 ohms R: Metal Film 1/4 W ±1%	75042	CEA-TO-4640-F
6-13	Change R163 to 62 ohms R: Metal Glaze 1/4 W ±5%	75042	RG1/4-620-J
	Delete R175		
6-14	Change Q16 to TSTR: Silicon NPN	04713	2N5289
	Change Q17 to TSTR: Silicon PNP	04713	2N3467

In Section VII on pages 7-5 and 7-9 (Figure 7-7) and on Detailed Schematic enclosed with the manual, make the following changes:

A1 Board

R67 should be 110 ohms (shown as 51 ohms)

A2 Board

C1 should be .47 mf (shown as 0.1 mf)
C3 thru C6 should be 0.1 mf (shown as 0.002 mf)
R30 and R24 should be 150 ohms (shown as 200 ohms)
R43 and R44 should be 464 ohms 1% (shown as 909 ohms 1%)
R163 should be 62 ohms (shown as 51 ohms)
R175 should be "Factory Select" (shown as 2.05K 1%)
Q17 should be 2N3467 (shown as MM4018)

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ENCLOSURE

The Detailed Schematic for Model F51A Function Generator is contained in envelope at rear of manual.

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Figure 1-1. Function Generator Model F51A

NOTES

Section I
GENERAL DESCRIPTION

1-1. INTRODUCTION

This manual has been carefully designed to complement the actual hardware design features of the F51A Function Generator by providing detailed operation data, extensive maintenance, and performance test information. However, the F51A Function Generator has been designed so that constant reference to the manual is not necessary in order to operate the unit. The manual has been designed to provide the operator with an in-depth understanding of the functions, maintenance, and troubleshooting of the unit, and to provide specific calibration laboratory tolerances, specifications, measurements, and adjustments in the event a malfunction occurs.

1-2. SPECIFICATIONS

Table 1-1 contains all key performance and physical specifications for the F51A Function Generator. Confirmation of performance within these specifications may be obtained by conducting the performance test routines presented in Section V of this manual. Outline mounting dimensions are shown in the installation diagram, figure 2-1.

1-3. DESCRIPTION

The Interstate F51A Function Generator is a compact, state-of-the-art signal source designed for great versatility, maximum ease of operation, and long operational life.

The case enclosing the F51A provides exceptional physical ruggedness and utility together with effective electrostatic shielding. The latter is important for the radio-frequency operating ranges of the instrument. Attention has been given to ground isolation applications and a grounding strap is provided at the rear of the instrument. The variable position handle permits the F51A to be tilted at the optimum angle for the operator. The handle facilitates carrying the unit and doubles as a cable strain relief when extended to the rear.

The serial number and other identification data are located on the metal plate at the rear of the instrument. This metal plate also serves as the primary heatsink for the power supply.

1-4. CAPABILITIES

The F51A Function Generator selectably provides the following broad selection of output waveforms from the two 50-ohm BNC front panel connections:

- Sine
- Square
- Triangle
- Ramp (15/85 duty cycle)
- Inverted ramp (85/15 duty cycle)

- Positive-going pulse (15 percent duty cycle)
- Negative-going pulse (15 percent duty cycle)
- Rectangular pulse with continuously variable duty cycle (100-nanosecond minimum pulse width)
- Any of the above offset positively with respect to ground
- Any of the above offset negatively with respect to ground

The calibrated frequency range of the F51A is from 0.0005 Hz to 11 MHz in 10 ranges, each covering a 20:1 ratio. External signals may be applied at the front panel to frequency modulate the main signal output by as much as 1000:1. The generator output frequency may be locked to an input reference by applying the external signal to the rear SYNC INPUT BNC connector.

A total output level variation of greater than 60 db may be realized in combination with the two front panel output BNC (HI output is 30 db greater than the LO output) and the 30 db variable attenuator. Maximum output level is 30 volts peak-to-peak into an open circuit (15 volts p-p into 50 ohms).

Any waveform may be manually offset up to ±10.0 volts subject to the limitation that the total voltage swing (d-c plus signal peak) may not exceed 15 volts into an open circuit. Also, a rectangular wave SYNC OUT signal (2 volts p-p in 50 ohms) is available at the front panel. This sync signal is a squarewave (50 percent duty cycle) for all settings of the variable pulse width control.

On rack mounted units of the F51A, three additional BNC connectors are options for ease and accessibility of rear cables. In this case, VCG INPUT, SYNC OUT, and the HI output terminals are duplicated on the rear of the chassis.

TABLE 1-1. TECHNICAL SPECIFICATIONS

WAVEFORMS:
Variable Amplitude: Sine, square, triangle, variable duty cycle pulses variable 5 to 95% of full duty cycle (100 nsec min), 15/85% fixed duty cycle positive and negative pulses and ramps. All waveforms symmetrical about ground. Output impedance is 50 Ω.

Fixed Amplitude: Sync Out. Squarewave except when fixed 15/85% duty cycle ramps or pulses are selected. Amplitude >2v p-p with 50Ω load, symmetrical about ground. Rise time <20 nsec; leads sine and triangle by 90^{o}, in phase with main squarewave.

FREQUENCY:
Sine, square, triangle waveforms 0.0005 Hz to 11 MHz, ramp and pulse waveforms 0.0005 Hz to 5 MHz. Ten decade ranges with 20:1 continuous vernier adjustment within any range.

DIAL ACCURACY:
Sine, square, triangle, and variable width pulse: <±1% of setting ±1 minor division to 500 kHz; <±3% of setting ±2 minor division 500 kHz to 5 MHz; <±5% of setting ±3 minor division 5 MHz to 11 MHz.

TIME SYMMETRY:
< 1% to 10 Hz; < 0.5%, 10 Hz to 100 kHz; < 2%, 100 kHz to 3 MHz; < 5%, 3 MHz to 11 MHz.

AMPLITUDE:
Attenuator: Two outputs HI (0 db) and LO (-30 db) with additional >30 db continuous vernier, total range >60 db.

Sine Flatness: Better than 0.1 db to 100 kHz; 0.2 db, 100 kHz to 1 MHz; 2 db, 1 MHz to 11 MHz.

Maximum Output: 15 v p-p into 50 Ω load; > 30 v open circuit. (Ramps and pulses: > 12 v p-p between 3 and 5 MHz.)

Amplitude Differential: Differential p-p between sine, triangle, square waveforms < 5% to 5 MHz.

SINE DISTORTION:
< 0.5% to 100 kHz; <1.0 100 kHz to 1 1 MHz; < 3% 1 MHz to 5 MHz; < 5% 5 MHz to 11 MHz.

NOTES: Except where indicated, specifications apply with 25^{o}C ±10^{o}C ambient, with 10 v p-p output level 50 Ω resistive load, and 0 vdc offset, frequency controls set between 1.0 and 11.0 on the frequency dial. All external inputs removed. Specifications subject to change without notice.

Table 1-1. Technical Specifications (Continued)

TRIANGLE LINEARITY:
>99% to 100 kHz; > 95% 100 kHz to 5 MHz.

SQUAREWAVE AND PULSES:
< 5% total abberation (to 5 MHz); rise and fall times < 30 nsec.

STABILITY:
Amplitude, frequency, and offset, better than 0.05% for 10 min; 0.25% for 24 hr.

VCG:
External d-c or a-c voltage control of output frequency; 0 to +10 v varies frequency upward 1000:1 from minimum dial setting; 0 to -10 v varies frequency downward 1000:1 from maximum dial setting. VCG bandwidth is 100 kHz limited to 0.3 v/μsec input impedance is 10 k Ω. Linear to within 0.2% on all ranges except 1M.

VARIABLE DUTY CYCLE PULSE WIDTH:
External voltage control of pulse duty cycle linear to within 1%. Input impedance is 2 k Ω.

EXTERNAL SYNC INPUT:
Periodic waveforms > 5 v p-p (100-v max) at sync input synchronizes output frequency when within 1% of the external frequency. (Pulse input waveforms are required on x100K and x1M ranges.) Input impedance is 10 k Ω.

DC OFFSET:
Selectable 0 vdc offset, positive or negative fixed offset with peaks tangent to 0 vdc and output reduced to half amplitude and variable offset adjustable ±10 v (signal plus offset < ±15 v) with open circuit. Offset is independent of variable attenuator setting.

ISOLATION:
Detachable ground strap may be removed to electrically isolate all BNC connectors and circuit grounds from case and power-line ground.

POWER:
115 or 230 vac ±10%, 50-400 Hz, 35 w max.

NOTES: Except where indicated, specifications apply with 25°C ±10°C ambient, with 10 v p-p output level 50 Ω resistive load, and 0 vdc offset, frequency controls set between 1.0 and 11.0 on the frequency dial. All external inputs removed. Specifications subject to change without notice.

Section II
INSTALLATION

2-1. INTRODUCTION

This section provides instructions pertaining to receiving, inspecting, and installing the equipment.

2-2. RECEIVING AND INSPECTION

Immediately upon receipt of the instrument, the exterior of the shipping container should be inspected for physical damage and the carrier notified if such is visible. After carefully removing all packing materials, the instrument should be inspected to insure that it is free of all mars and blemishes.

Electrical performance that meets or exceeds the specifications (Section I, Table 1-1) should be confirmed as soon as possible. Section V contains a suggested performance test routine and the test equipment recommended.

2-3. INSTALLATION

This instrument may be used on the workbench or rigidly mounted in a RETMA rack structure by means of an optional rack-mounting kit (see figure 2-1 for details of single and double unit rack assemblies). As initially shipped, the instrument is provided with a rugged, adjustable handle that facilitates carrying as well as tilting for optimum panel viewing angle.

This all solid-state instrument requires no special cooling facilities so long as it is operated within the temperature limits specified in table 1-1.

2-4. POWER REQUIREMENTS

This instrument operates from a-c power only, either 115 or 230 vac, 50 to 400 Hz. A slide switch at the rear of the equipment readily selects the desired power line voltage.

CAUTION

Operation at the wrong power line voltage switch setting may damage the instrument.

A three-conductor cord is supplied with the equipment to permit referencing the chassis and case to power system ground. This safety feature is recommended by the National Electrical Manufacturers Association (NEMA). The offset pin on the power cord connector is the ground wire.

2-5. REPACKAGING

If it becomes necessary to pack the instrument for shipment, the following procedure is recommended.

a. Attach a tag with the owner's name, address and telephone number together with a

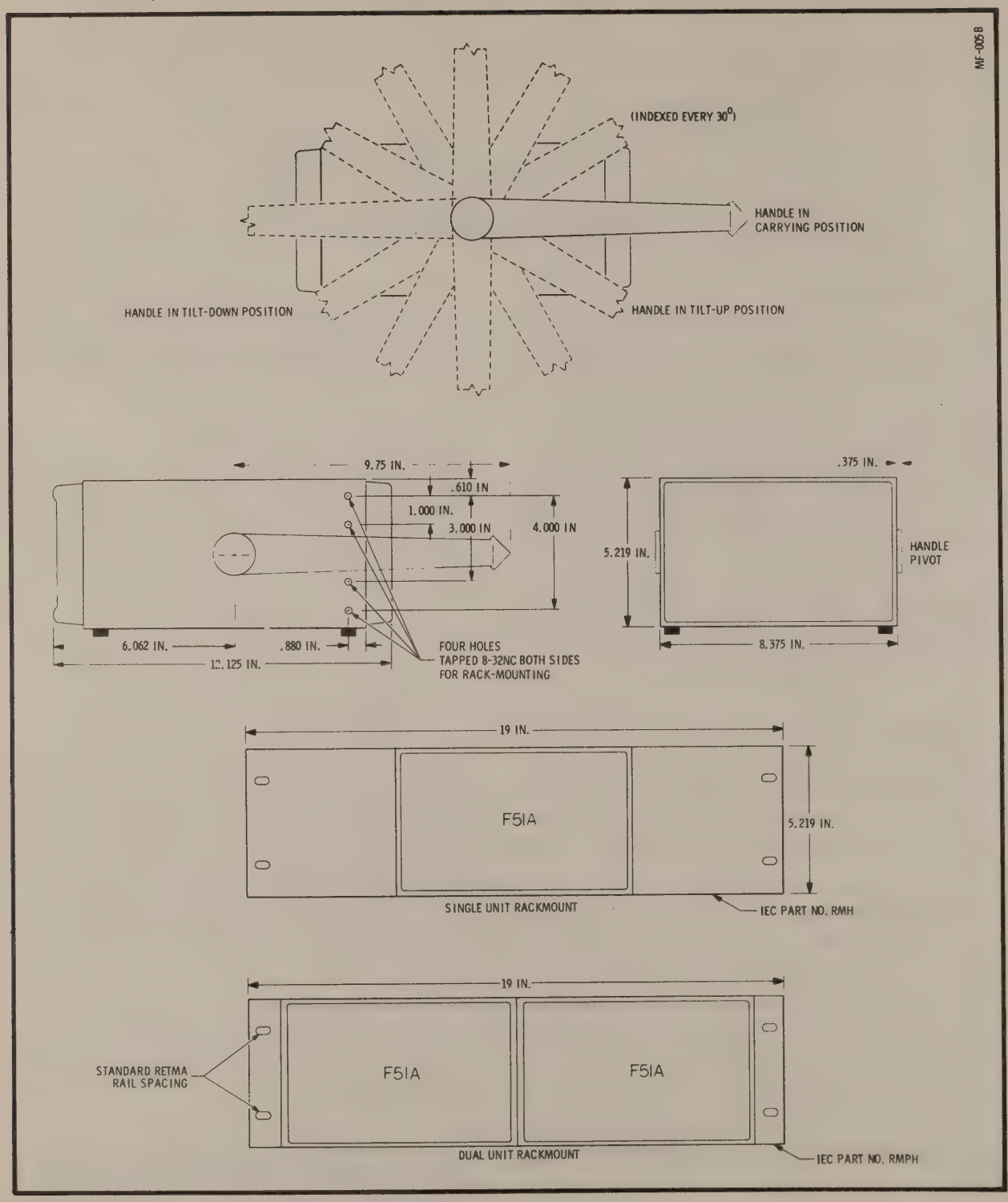


Figure 2-1. Installation Detail

brief description of the purpose of the shipment and the date its return is desired.

b. Wrap the equipment in heavy paper or plastic before placing in an inner container.

c. Use soft packing material liberally around all sides of the instrument inside the inner container.

d. Enclose the inner container in a rugged carton or wood box with suitable packaging material to prevent movement in any direction and seal the outer container with heavy tape or metal bands.

e. Mark the shipping container with the shipping address and "DELICATE INSTRUMENT" labels.

2-6. DISASSEMBLY

To remove the function generator from its case, remove the four retaining screws mounted in the heatsinks and ground strap at the rear of the unit and two retaining screws from the bottom of the unit. Withdraw the chassis through the front of the case. Access to the boards and front panel is obtained as follows:

(1) Remove the four screws (two upper, and two lower) from the top and bottom of the plastic faceplate (figure 2-2). This will expose the upper and lower front subpanels and controls.

(2) Remove the two retaining screws at the bottom of the A2 board, near the front, outer edges. (See figure 2-2.) These screws are seated in two spacers permanently mounted on the A1 board. The A1 and A2 boards, and their respective front subpanels, will then open bookfashion at the front edges.

NOTE

The hinge assembly at the rear of the A2 board is a permanent fixture and need not be dismantled or removed to gain normal access to the boards.

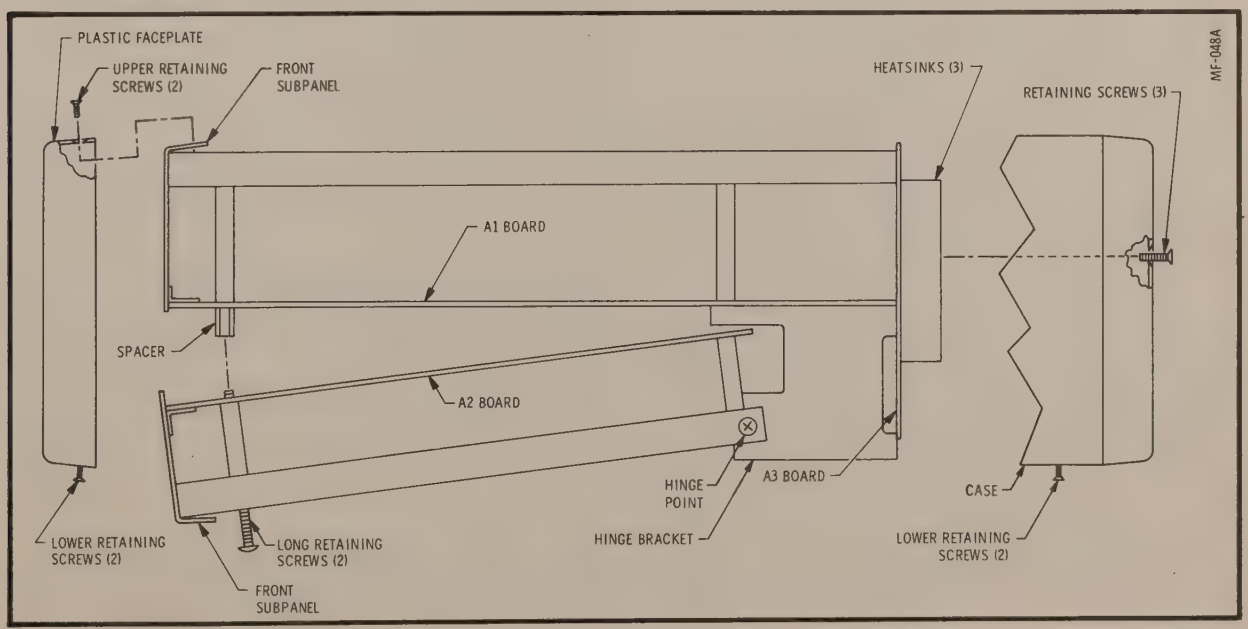


Figure 2-2. Disassembly Diagram

NOTES

Section III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION

Operation of the F51A Function Generator is simple and straightforward. Normally, an operator will be able to operate the instrument without reference to the manual; however, this section will provide operating tips and assistance to anyone not familiar with this type of equipment. Refer to figures 3-1 and 3-2 for identification of front and rear panel controls and indicators. Table 3-1 lists the functions of the front-panel controls and indicators and table 3-2 lists the functions of the rear panel connectors and fuse.

3-2. GENERAL INFORMATION

The calibrated 20:1 frequency dial provides a 50-percent overlap with adjacent bands as selected by the MULTIPLIER range switch. The ten decades of the MULTIPLIER switch permit the instrument to be tuned over the frequency range of 0.0005 Hz to 11 MHz.

Any of the eight standard waveforms may be selected with the WAVEFORM switch. The concentric variable pulse width (VAR PULSE) control (inhibited except when the variable pulse is selected by the WAVEFORM switch) permits varying the duty cycle of a rectangular waveform.

The desired output waveform is provided simultaneously at the LO and HI output connectors. These outputs differ by 36 db when both are terminated with 50-ohm loads. The OUTPUT LEVEL control provides a minimum additional attenuation of 30 db, continuously variable.

The OFFSET control establishes the waveform polarity with respect to ground. The output may be selected to be symmetrical, all positive, all negative, or continuously adjustable about ground. The concentric ADJUST offset control (inhibited except in the ADJ position of the OFFSET switch) provides ±10.0 volts offset range into an open circuit and ±5.0 volts into a 50-ohm load.

The frequency of the instrument may be varied by an external voltage applied to the VCG INPUT connector on the front panel. A full 1000:1 frequency change may be obtained from +10 volts when the frequency dial is set at the low limit, and conversely, from -10 volts with the frequency dial set at the upper limit.

The SYNC OUT signal is a 4 volt p-p (open circuit, 2 volt p-p into 50 ohms) rectangular wave that is in phase with the main output square waveform. The SYNC OUT signal assumes the same duty cycle as the fixed ramp and pulse outputs; however, for variable pulse width operation, the SYNC OUT is 50/50 duty cycle.

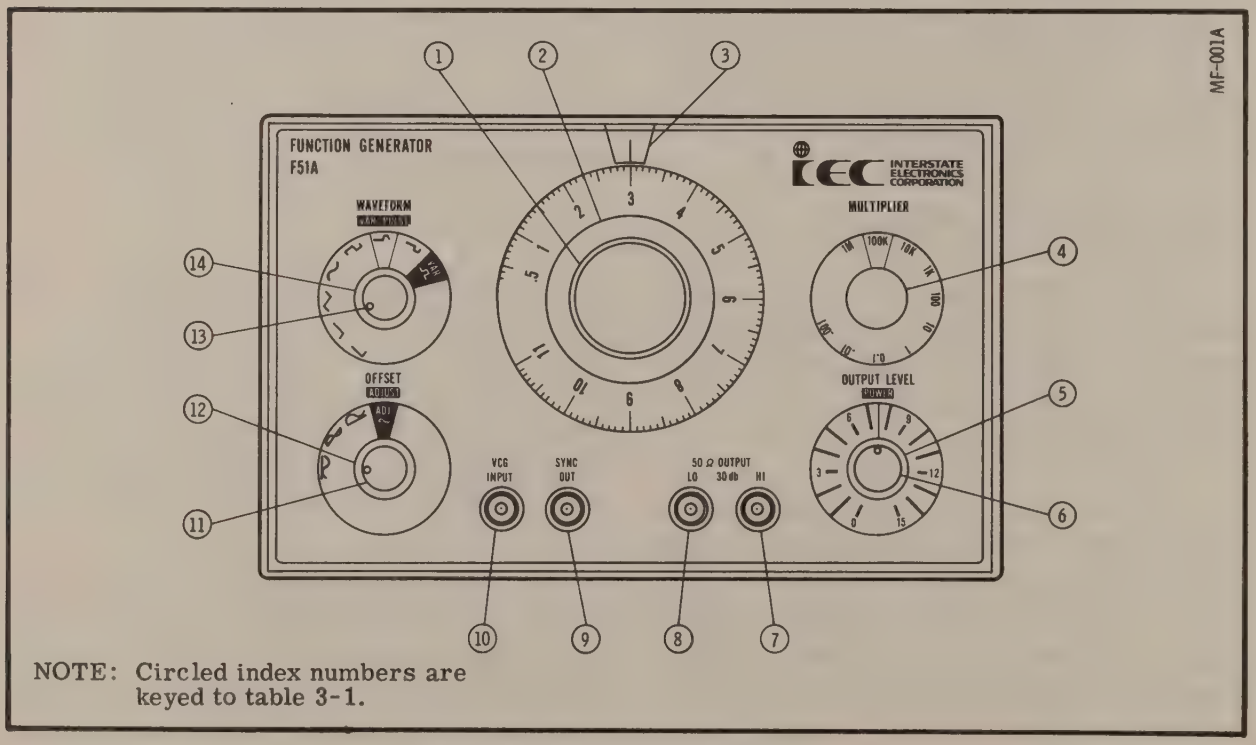
3-3. OPERATING TIPS

a. FREQUENCY MODULATION. - Any output frequency may be frequency modulated up to a 100 kHz rate with an a-c signal of peak-to-peak value less than 10 volts into the VCG INPUT.

b. OFFSET. - The sum of the d-c offset plus the signal peak value can not exceed ±15 volts into an open circuit (±7.5 volts into 50 ohms).

c. PULSES AND RAMPS. - The extremely fast rise times and slew rates of the F51 circuitry permit practical pulse durations of less than 100 nanoseconds; however, pulse and ramp waveforms above 3 MHz will experience degradation with increasing frequency. The fastest possible rise times (less than 20 nanoseconds) are available at the SYNC OUT connector because of the reduced fixed amplitude. It will be noted that the nature of the variable pulse width circuits causes a variable delay between the SYNC OUT and the main output waveform as the pulse width is adjusted.

d. WAVEFORM PURITY. - The 50-percent frequency overlap of adjacent ranges will often make it possible to tune to the desired frequency on either of two MULTIPLIER ranges. Select the lower MULTIPLIER range for maximum waveform purity.



NOTE: Circled index numbers are keyed to table 3-1.

Figure 3-1. Controls and Indicators

TABLE 3-1. FUNCTIONS OF CONTROLS AND INDICATORS

Index No.	Function	Index No.	Function
1	Fine frequency knob: Adjusts frequency dial in 6:1 ratio.		main generator output squarewave. Signal is 4 volts peak-to-peak (open) or 2 volts peak-to-peak (into 50 ohm load).
2	Coarse frequency knob: Adjusts frequency dial in 1:1 ratio.	10	VCG INPUT: Provides connector for voltage controlled generator input to control the output frequency.
3	Dial cursor and pilot indicator: Glows when power is applied to instrument.	11	ADJUST: Provides continuously variable d-c offset when OFFSET switch is in ADJ position, independent of OUTPUT LEVEL control.
4	MULTIPLIER: Selects multiplying factor for frequency dial.	12	OFFSET: Selects waveform offset with respect to ground. Positive and negative going functions are half amplitude.
5	OUTPUT LEVEL control: Provides continuous adjustment of output level between 0 and -30 db.	13	VAR PULSE: Varies pulse width by changing duty cycle when WAVEFORM switch is in VAR ⎍ position.
6	POWER (ON-OFF switch).	14	WAVEFORM: Selects desired output function. Activates VAR PULSE knob for variable pulse width function.
7	HI output: Provides connector for all output functions. Maximum output level is 30 peak-to-peak (open) or 15 volts peak-to-peak (into 50 ohm load).		
8	LO output: Output for all functions. Signal level is 30 db below HI output.		
9	SYNC OUT: Provides connector for a rectangular wave output in phase with		

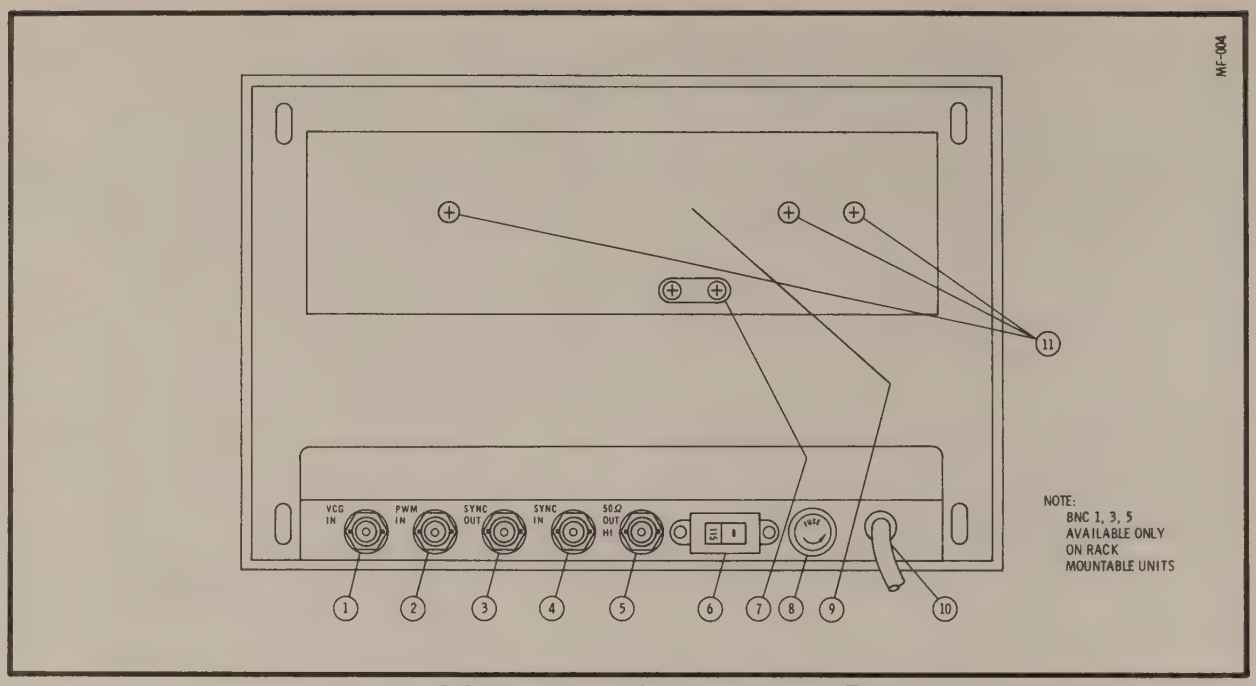


Figure 3-2. Rear Panel Connectors and Fuse

TABLE 3-2. FUNCTIONS OF REAR PANEL CONNECTORS AND FUSE

Index No.	Function	Index No.	Function
1	VCG: Provides connector to apply external d-c or a-c voltages to frequency-modulate the output frequency.		ohm load.) Output impedance 50 ohms.
		6	Line Voltage Switch: Selects 115 vac or 230 vac.
2	PWM: Provides connector to pulse width modulate the variable pulse-width output.	7	Ground Strap: Permits signal ground to be isolated from case ground.
3	SYNC OUT: Provides connector for rectangular output of 2 volts peak-to-peak into 50 ohm load.	8	Fuse: 1/2 amp, slo-blo for 115 vac: 1/4 amp slo-blo for 230 vac line voltage
4	SYNC IN: Provides connector for external frequency input to synchronize the generator output.	9	Rear Panel: Primary heat sink for power supply.
		10	Line Cord: 3-wire type to permit grounding case.
5	HI output; Provides connector for output of 30 volts peak-to-peak (open) or 15 volts peak-to-peak (into 50	11	Retaining screws (3)

Section IV
THEORY OF OPERATION

4-1. INTRODUCTION

This section contains a detailed description of the F51A Function Generator. Each functional section is discussed with its own block diagram to facilitate easy understanding. Throughout the manual, all components are prefixed by the board number.

4-2. OVERALL FUCTIONAL DESCRIPTION

The complete block diagram is shown in figure 4-1. This diagram illustrates the interrelationships of all of the functional sections which are discussed in the following paragraphs. A more detailed block diagram is shown on figure 7-1, and circuit board detailed schematics are shown on figures 7-2, 7-3, and 7-4.

The F51A can be divided into ten functional sections. Each of these are explained in a logical progression:

- Frequency Control
- Voltage-to-Current Converter
- Triangle Amplifier
- Inverter Amplifier
- Automatic Level Control
- Voltage Level Sensor
- Sine Shaper
- Variable Pulse Width Shaper
- Output Amplifiers
- Power Supply

4-3. FREQUENCY CONTROL AND VOLTAGE-TO-CURRENT CONVERTER

The frequency control section makes up the "front end" of the function generator. Inputs are single-ended control voltages from the main frequency potentiometer or from an external voltage source. The voltages are scaled, inverted, and offset by the frequency control circuits.

The voltage-to-current converter interfaces with four related output voltages from the frequency control section. By means of precision resistor networks and closed-loop amplifiers, these voltages are converted to proportional, equal and opposite, switchable currents. The currents, of appropriate magnitude, when switched under controlled conditions into an integrating capacitor, determine the frequency of the function generator.

Figures 4-2 and 4-3 show the essential elements of the frequency control and voltage-to-current converter circuits in block diagram form.

a. FREQUENCY CONTROL. - As shown in figure 4-2, two controlling voltages (from the main frequency dial control or from an external source, if used) are summed at the input to the first inverting amplifier. A fixed, positive level offset voltage is also summed at the same

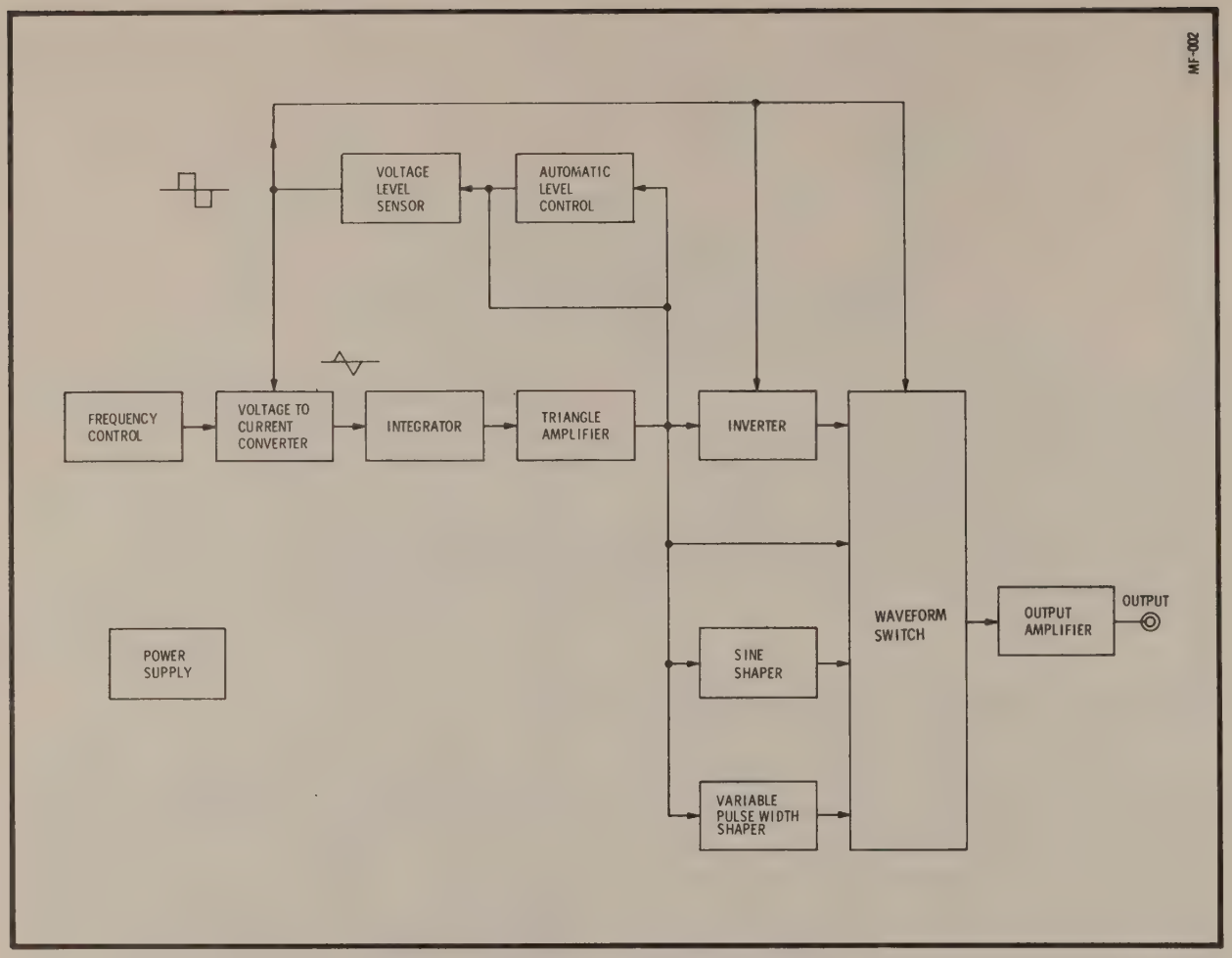


Figure 4-1. Simplified Block Diagram

point. Full frequency control range, represented by a zero to +10 volts excursion at the input, becomes an offset -7.5 volts to -17.5 volts excursion at V_B, the output of the first inverting amplifier. The second inverting amplifier furnishes an equal but opposite voltage, V_A, exhibiting an excursion between +7.5 volts and +17.5 volts. The fixed voltages V_C and V_D are established as references. The subsequent section will utilize the terms $(V_A - V_C)$ and $(V_B - V_D)$ in converting to a zero current reference. Summation of V_C and V_D at the + input to the second inverting amplifier causes the terms $(V_A - V_C)$ and $(V_B - V_D)$ to track power supply variations proportionally.

In the following detailed analysis of the frequency control section refer to the schematic, figure 7-2. The setting of the main frequency control A1R4 establishes a voltage at A1TP1 between 0 and +10 volts. This voltage is calibrated by adjustable resistor A1R2 for a midrange frequency. Other frequency ranges are calibrated by resistors A1R5, A1R7, and A1R201. Resistive summing via A1R144, A1R145, and A1R147 combines the main frequency control voltage with an offset derived from +12 volts, and with an external

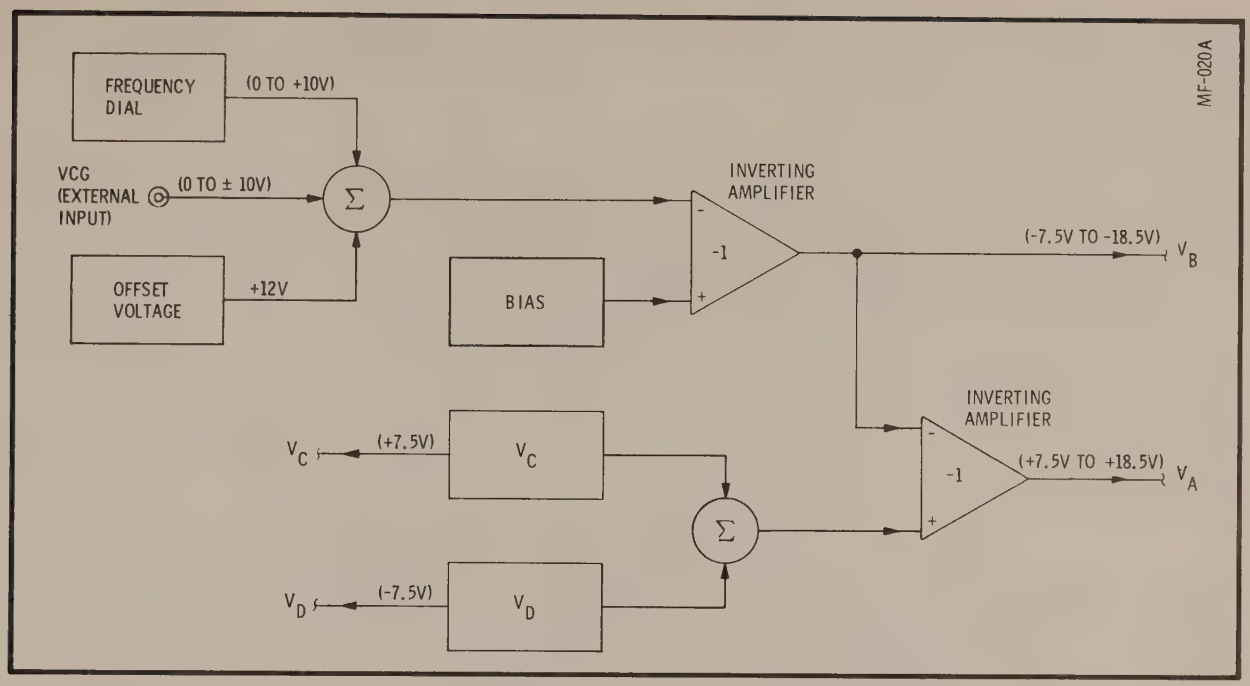


Figure 4-2. Frequency Control, Block Diagram

voltage when used in a voltage controlled generator (VCG) mode. Operational amplifiers A1IC6 and A1IC7 develop the negative control voltage V_B and the inverted positive control voltage V_A respectively. The range of operation of V_A is +7.5 volts to +17.5 volts, and V_B from -7.5 volts to -17.5 volts. A resistive divider network derives nominal ±7.5 volts reference voltages V_C and V_D from the ±12 volts power supplies. Potentiometer A1R162 is employed as a symmetry adjustment for obtaining 50/50 duty cycle waveforms.

b. VOLTAGE-TO-CURRENT CONVERTER.- With reference to figure 4-3, the voltage difference terms $(V_A - V_C)$ and $(V_B - V_D)$ are impressed across the ramp and range resistive networks. The differencing is mechanized by means of operational amplifiers connected as voltage followers. Field effect transistors at the follower outputs serve to translate the voltages to currents i_A and i_B between the differing voltage levels at the follower and at the diode bridge current-steering switch. Alternate charging and discharging of the selectable integrating capacitors at the diode bridge output, under control of the square wave, result in the desired triangular waveform.

The ramp and range networks are series-parallel combinations of resistors which determine the magnitude of currents i_A and i_B in accordance with control voltages $(V_A - V_C)$ and $(V_B - V_D)$, the selected frequency range and either a symmetrical 50/50 duty cycle or a 15/85 ramp. For 50/50 duty cycle operation, the series ramp network at V_A is shorted out, and the parallel network at V_B is opened. When a ramp function has been selected, the insertion of the series network reduces i_A by approximately 40 percent and the connection to the parallel network increases i_B to 333

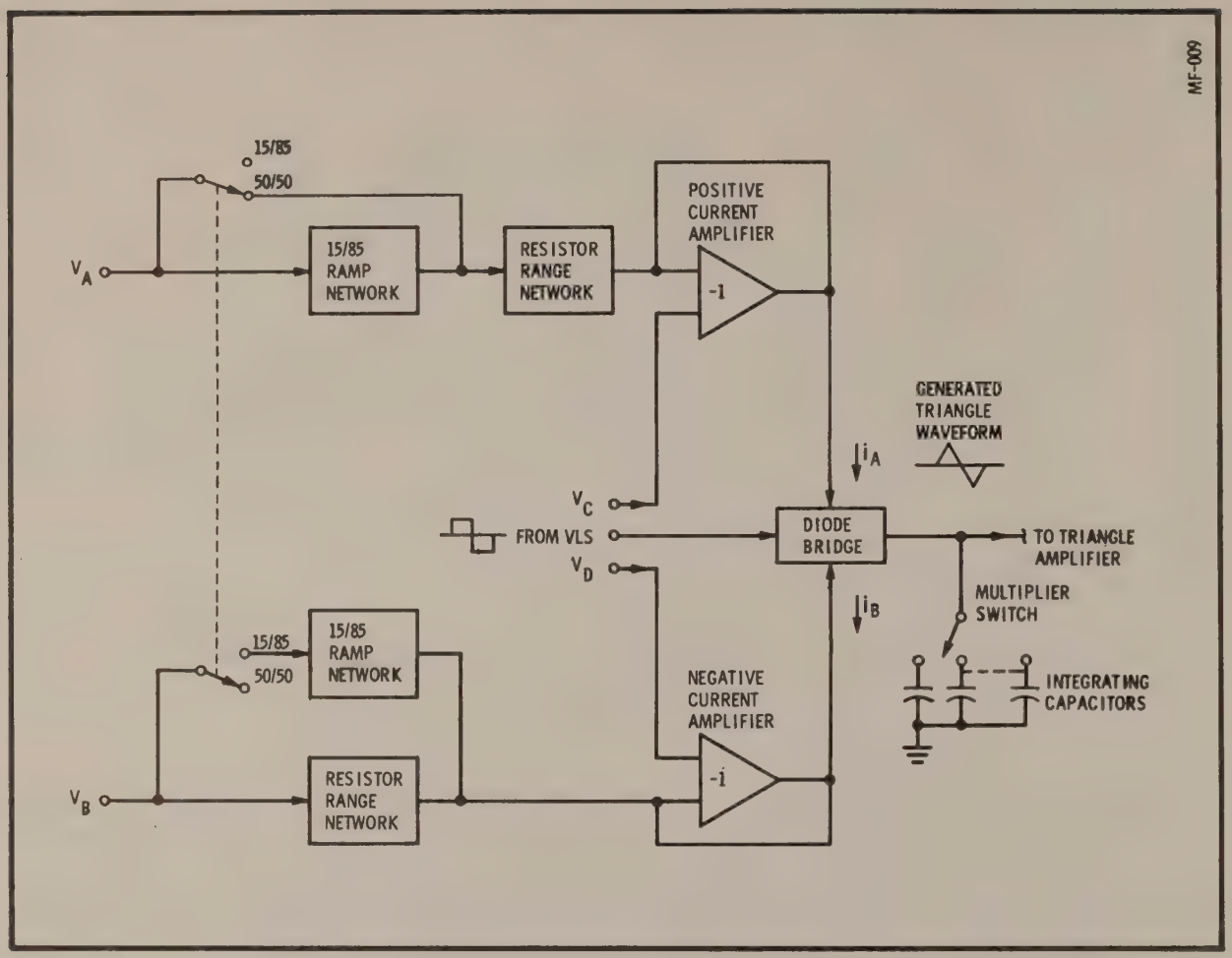


Figure 4-3. Voltage-To-Current Converter,Block Diagram

percent. This satisfies the conditions necessary to generate the required voltage ramps at the integrating capacitors.

In the following detailed analysis of the voltage-to-current converter, refer to the schematic, figure 7-2. Voltages V_A and V_C are impressed across the MULTIPLIER switch network A1R8 through A1R16. The resultant current flow is dependent upon both the MULTIPLIER setting and WAVEFORM selection. Similarly, an opposite polarity current is developed by the network A1R17 through A1R25. The relationship between the two opposite polarity currents is modified by the WAVEFORM switch in accordance with the 15/85 duty cycle capability, by means of series network A1R26, A1R27, A1R29 through A1R33 and parallel network A1R34 through A1R41. When these networks are inserted, the resultant current from V_A is reduced to 50/85 of nominal, and the current from V_B is increased to 50/15 of nominal. The resultant integrator waveform exhibits a 15/85 duty cycle, with negligible shift of frequency from the nominal 50/50 condition.

(1) Integrated circuit amplifiers A1IC1 and A1IC2 form the basis for active current sources. Due to the wide range of currents to be accommodated (approximately 2 na to 25 ma), field-effect buffers are required at input and output. The resultant performance approaches an ideal current source at low frequencies (<100 kHz) due to the high voltage gain of the amplifiers. At high frequencies (>100 kHz) the intrinsic output impedance of transistors A1Q3 through A1Q6 give less perfect, but adequate, approximations to current source operation.

(2) Diodes A1CR1 through A1CR8 make up a current-steering bridge. When A1TP7 is low (-3 volts), current will flow towards that test point from the upper (positive) current source. The lower (negative) current source will then accept current from the integrating capacitor through diodes A1CR5 and A1CR6. When A1TP7 goes high (+3 volts), currents will interchange via the bridge. Note the use of two series diodes in each log of the bridge. This is necessary because of the conflicting requirements of low leakage and low stored charge at extremes of the function generator frequency range. These characteristics are not obtainable to the required degree in a single diode.

(3) Integrating capacitors A1C22 through A1C27 are selected in accordance with the desired MULTIPLIER switch setting. The highest frequency range incorporates an adjustable capacitor for purposes of frequency calibration.

4-4. TRIANGLE AND INVERTER AMPLIFIERS

The triangle amplifier is a wideband, potentiometric, gain-of-four amplifier. Its purpose is to buffer the integrating capacitor as well as to furnish a low-impedance 6 volt p-p signal

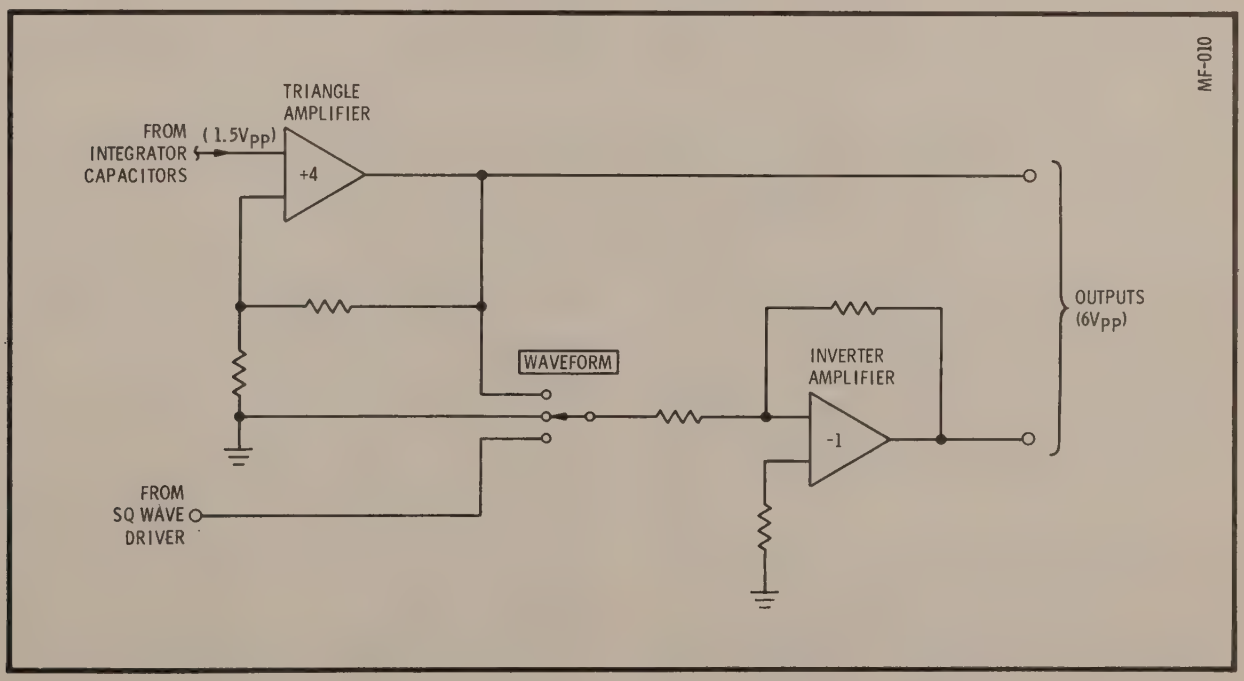


Figure 4-4. Triangle and Inverter Amplifier, Block Diagram

for succeeding circuitry. The inverter amplifier is of similar design, except that it is connected as a gain-of-minus-one amplifier to supply an inverted waveform with respect to the triangle amplifier output. The inverted waveform is utilized for reversed polarity ramp and pulse functions.

The block diagram, figure 4-4, shows the input/output relationship of the triangle and inverter amplifiers. The configuration is quite conventional. A major consideration is the potentiometric configuration of the triangle amplifier for obtaining extremely high input impedance. Not shown in the block diagram, but essential for the low-frequency ranges of the function generator, is a low-input-current, dual field-effect transistor A1Q7.

a. TRIANGLE AMPLIFIER. - Field effect transistor A1Q7 is connected as a source follower, driving the differential transistor array A1IC3A. Due to the wideband requirements of the amplifier, A1IC3 incorporates high -frequency transistors (f_T > 1000 MHz). Again, in order to maintain wideband response, the output A1IC3A is coupled through common-base amplifier A1Q8 to the complementary emitter-follower output drivers A1Q9 and A1Q10. DC feedback is applied via A1R121 and A1R123, establishing an overall voltage gain of four. High-frequency feedback is coupled through A1C31, which is adjustable for purposes of shaping overall high-frequency response.

b. INVERTER AMPLIFIER. - Essentially identical design approach is employed as for the triangle amplifier, except that it is simplified by elimination of the field-effect transistor input. The circuit shares one-half of array A1IC3 and d-c biasing networks with the triangle amplifier. Feedback resistors A1R75 and A1R76 establish a nominal gain of minus one.

4-5 VOLTAGE LEVEL SENSOR AND AUTOMATIC LEVEL CONTROL OPERATION

The combined function of the VLS-ALC circuits is one of determining the point at which the main integrator ramp is caused to reverse slope. Refer to the block diagrams, figures 4-5 and 4-6. The VLS is essentially an ultra-fast comparator, referenced to a pair of adjustable d-c reference levels (one being positive, the other negative).

The ALC is necessary on the two highest frequency ranges only as a means for loop delay compensation. Without the ALC, the main loop performance would be severely limited at the high-frequency end due to the effect of propagation time around the loop (≈25 ns). Together, the VLS and ALC form a peak amplitude regulator, with the error signal being the difference between a fixed d-c reference voltage and the peak (rectified) output of the triangle amplifier. In turn, the amplified error signal becomes a variable reference level to the VLS. Should the triangle amplifier peak amplitude now vary from its established value (due to integrator loop delay of ≈25 ns), the resultant error signal will automatically cause the VLS comparison level to shift in the proper direction for a reduced error.

Note that the SYNC IN signal also drives the VLS. Sync circuits provide for frequency-locking the function generator to an external source of sync pulses. Synchronization is achieved whenever a sync input pulse occurs within a period of 0 to -1 percent of the triangle peak. In essence, this implies that the sync pulse frequency (or a harmonic thereof) must be within 0 to +1 percent of the frequency

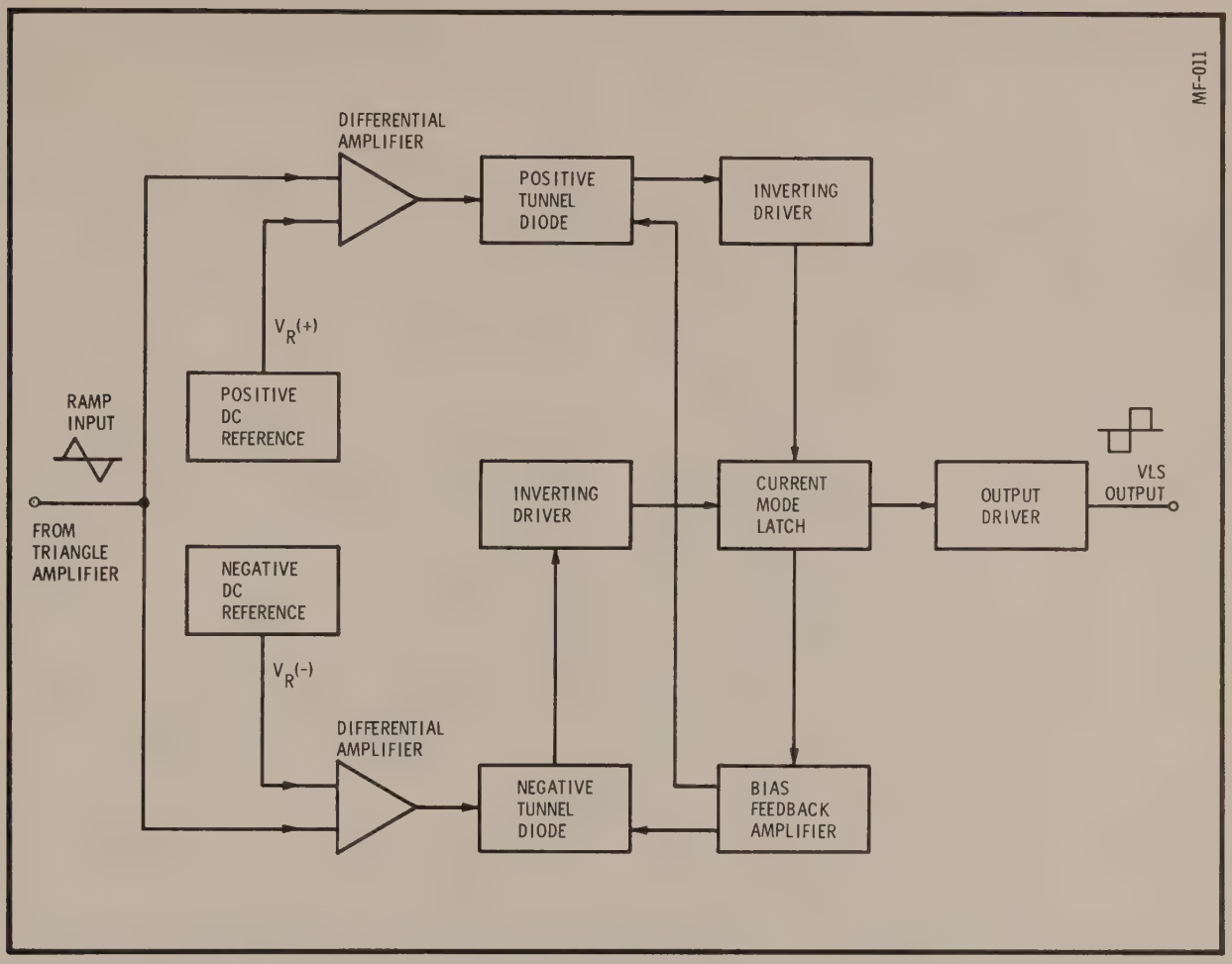


Figure 4-5. Voltage Level Sensor, Block Diagram

established by the free-running function generator. The sync function is implemented by a transistor switch which causes a reduction of 1 percent in the d-c reference level to the VLS.

a. VOLTAGE LEVEL SENSOR. - The VLS (figure 4-5) accepts a bi-directional ramp voltage waveform, and by means of two difference amplifiers, compares the input waveform against positive and negative reference levels. As the ramp input approaches V_R (+), the output current from the positive difference amplifier increases. When the positive tunnel diode current reaches its characteristic peak point, it will trigger on. The increased voltage drop across the on diode is coupled through an inverting driver to reset the current mode latch. (The reset condition of the latch is defined as a negative output voltage level with respect to ground.)

The bias feedback amplifier senses the state of the latch and feeds back conditioning levels to the tunnel diode circuits. The need for this feedback is dictated by the requirement for minimal recovery time.

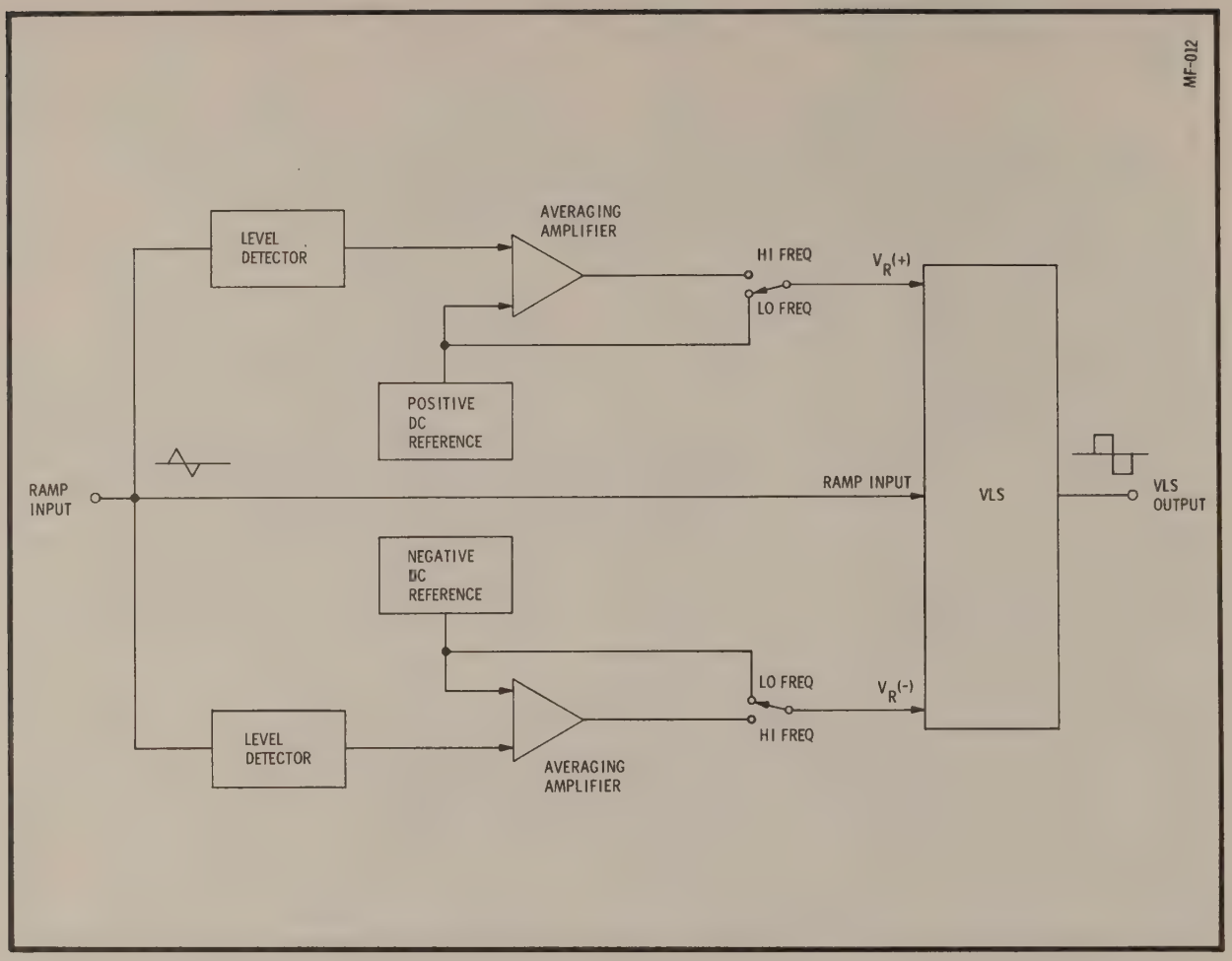


Figure 4-6. Automatic Level Control, Block Diagram

As the input ramp approaches $V_R(-)$, the output current from the negative difference amplifier increases, causing the negative tunnel diode to trigger on. In turn, an inverting driver will set the current mode latch. The cycle is completed as the bias feedback amplifier again changes state in response to the toggling of the latch.

In the more detailed discussion which follows, refer to the schematic diagram, figure 7-3.

(1) DIFFERENCE AMPLIFIERS. - Transistor arrays A1IC4 and A1IC5 accept the integrator ramp waveform and reference levels $V_R(+)$ and $V_R(-)$. As the positive-going input voltage (A1TP14) approaches $V_R(+)$ (A1TP17), there is an increased current flow at pin 12 of IC4. This current flow adds to the bias current of tunnel diode A1CR25. When $e_{in} \approx V_R(+)$, total current will be sufficient to fire A1CR25, causing an increased voltage drop across the diode. This voltage increase will be sufficient to turn on A1Q24.

(2) CURRENT-MODE LATCH. - The transistor pair A1Q19 and A1Q21 form a current-mode latch, so that the turn-off of A1Q21 causes the turn-on of A1Q19. As A1Q21 turns off, its collector drops towards the -3 volts zener clamp level established by A1CR35. The A1Q21 collector level is coupled through driver transistors A1Q34, A1Q22, and A1Q23 to the VLS squarewave output A1TP7.

(3) BIAS FEEDBACK AMPLIFIER. - Transistor pair A1Q18 and A1Q20 is a differential pair connected to provide a bias feedback function. When A1Q21 turns off, it also turns off A1Q20 (and turns on A1Q18). The immediate effect is the reverse biasing of tunnel diode A1CR25, and also causing tunnel diode A1CR22 to be forward biased slightly below its firing current level. Potentiometer A1R133 is provided to adjust the drive signal for optimum settling of the switched currents.

(4) RAMP REVERSAL. - Once diode A1CR25 has fired, the input voltage ramp will reverse to become negative-going. As this ramp approaches V_R (-) A1TP18, there is an increased current flow at pin 5 of A1IC5. This current flow adds to the bias current of tunnel diode A1CR22. When $e_{in} = V_R$ (-), total current will be sufficient to fire A1CR22. The firing of A1CR22 will cause A1Q17 to turn on, towards +12 volts. This rise of voltage is transmitted through A1CR21 to reverse bias A1Q19. Latch A1Q19 and A1Q20 reverses state, causing the output to change from -3 volts to +3 volts.

Following the reverse biasing of A1Q19, bias current transfers from A1Q18 to A1Q20, in turn, causing the reverse biasing of A1CR22 and the partial forward biasing of A1CR25. At this point, the input ramp reverts to positive-going and the previously described sequence of events is repeated.

b. AUTOMATIC LEVEL CONTROL, - ALC configuration is illustrated in figure 4-6. Peak level detectors provide a means for comparing the actual peak ramp voltages against pre-established reference levels. The overall closed-loop operation is such that positive and negative peaks are independently regulated. Without the ALC, a VLS and main loop integrator delay totaling 25 ns would cause a 2-to-1 variation in ramp amplitude as frequency is varied between 1 MHz and 10 MHz. With the ALC, amplitude variation due to delay becomes negligible, with second-order effects (such as peak detector inefficiency) becoming the limiting factors at the highest frequency.

In the following more detailed description, refer to the schematic diagram figure 7-2. The high-frequency ramp waveform is peak-rectified via matched diodes A1CR12 and A1CR13. Operational amplifiers A1IC8 and A1IC9, connected as integrators, provide d-c gain. Selection between either the amplifier outputs or fixed d-c reference levels is made on the basis of frequency range. The complete ALC loop extends from the amplifier outputs to the VLS reference inputs, then to the main integrator, and back around to the peak detectors.

4-6. SYNC INPUT

The sync circuit is simply a switch-controlled attenuator. With reference to figure 4-7, the presence of a pulse on the sync input line will cause an attenuation of the VLS reference

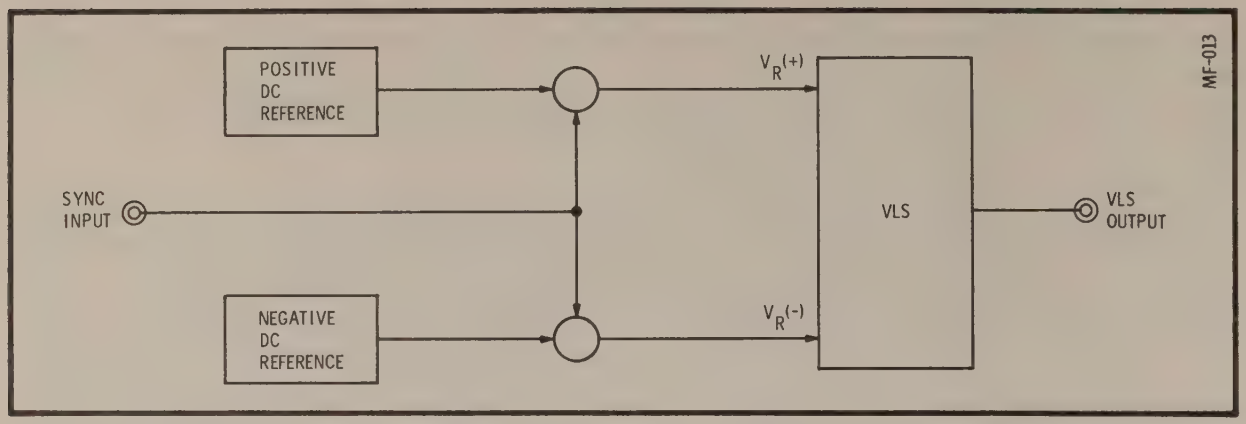


Figure 4-7. Sync Input, Block Diagram

voltage V_R (+) or V_R (-). Should this pulse coincide within 1 percent to the peak of the integrator ramp waveform, a reversal of the ramp will be forced. The net result, over the limited range of 1 percent, is the ability to cause the function generator to synchronize to an external train of pulses.

Either transistor A1Q13 or A1Q14 is driven on by the presence of a synchronizing pulse of 1 volt or more. A positive synchronizing pulse must coincide within limits to the positive ramp peak, and similarly for the negative pulse and peak. The resultant attenuation of the reference level to the VLS will force synchronization of the ramp to the pulse.

4-7. SINE SHAPER

The sinusoidal signal that is available as one of the functions generated by the F51 is produced by applying the triangular waveform of the main loop to a nonlinear network having an input-output relationship as shown in figure 4-8.

The sine shaper block diagram is illustrated in figure 4-9. The triangular waveform driving

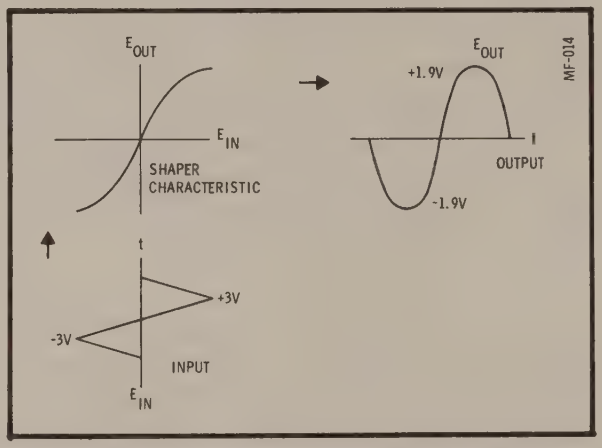


Figure 4-8. Sine Shaper Input/Output Diagram

the sine shaper has a peak-to-peak value of 6 volts.

Because of the sine shaping process, the output peak value of the resulting sinewave will be 1.9 volts. In order to obtain a sinusoidal waveform of the same amplitude as the incoming triangular waveform, an amplifier is needed, and its gain must be 1.57.

The transfer characteristic shown in figure 4-8 is obtained by means of a network of resistors and voltage-controlled switches such that

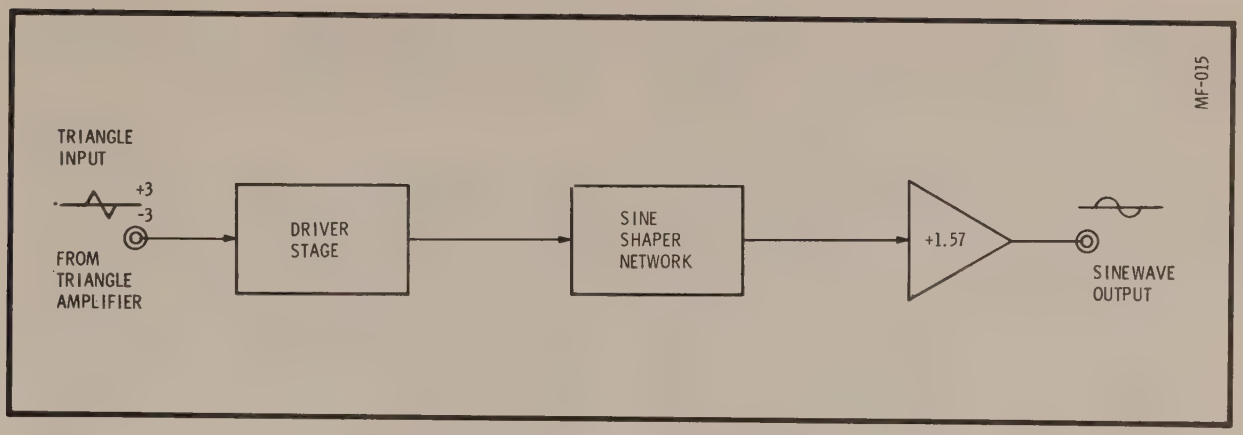


Figure 4-9. Sine Shaper, Block Diagram

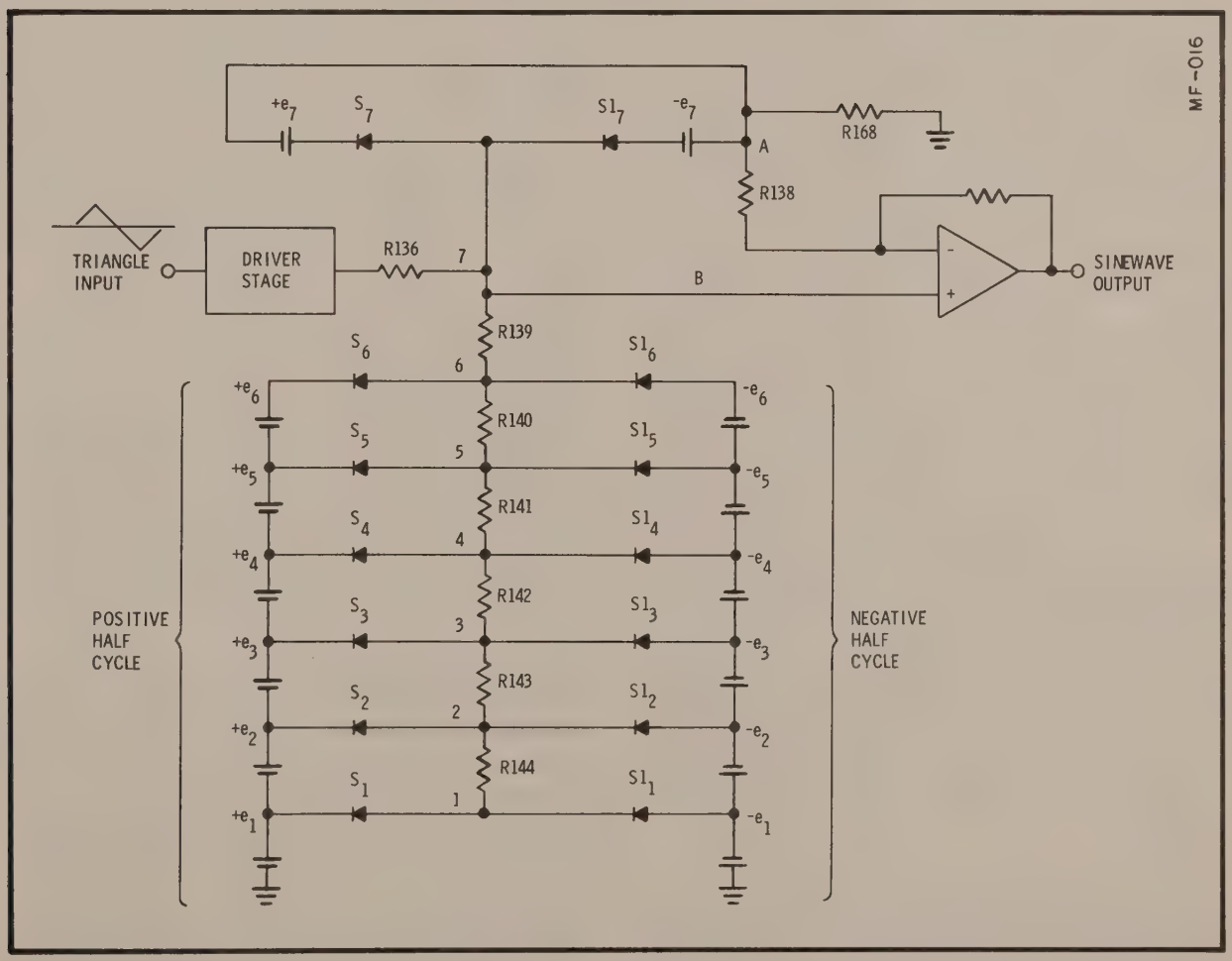


Figure 4-10. Sine Shaper Network

a nonlinear resistance is produced. The operation of this network is illustrated symbolically in figure 4-10. The diode switches in the figure represent transistors in the actual circuits. Each switch will conduct whenever the voltage at the ladder network point to which it is connected reaches the bias level of the point to which it is returned.

Consider the triangular waveform shown at the driver input. At zero volts, all switches are open, and the signal appears unchanged at output A. As the voltage increases in the positive direction, a point is reached where the voltage at node 1 is e_1, and switch S_1 closes. This clamps node 1 to voltage $+e_1$ for as long as the input voltage exceeds $+e_1$ volts. As the input voltage continues to rise, the voltage at node 2 eventually turns on S_2, clamping node 2 to voltage $+e_2$. This continues until the input reaches +3 volts, each successive switch clamping its corresponding node to a higher voltage. The net result is that the series string of resistors A2R139 through A2R144 presents an increasing load to the signal through A2R136, and the output waveform bends smoothly in a close simulation of a sinewave. The effect of switch S_7 is somewhat different. This switch closes just before the peak of the input triangle is reached, and its current passes through A2R168 to ground. The voltage drop through A2R168 generates the waveform shown at output point A. This is subtracted from the B signal by the differential amplifier, to remove the remaining discontinuity at the peaks of the B waveform.

In the downward travel of the input signal, this action reverses, and switches S_7 through S_1 are opened one at a time as the switch bias voltages are reached. The negative portion of the cycle is now handled by switches $S1_1$ through $S1_7$ in a similar manner.

The clamping switches used in the actual circuit are emitter followers, with their bases accurately biased by a precision resistive network. This provides a low impedance path to ground for the signal currents, and minimizes fluctuations in the bias voltages that might be caused by the flow of the signal currents through the bias resistors. As a result, the lower impedance network provides improved high frequency characteristics.

In the following detailed analysis of the sine shaper refer to the schematic, figure 7-3.

a. INPUT DRIVER. - This circuit comprises transistors A2Q34, A2Q35, A2Q36, and A2Q37. The dual complementary emitter-follower arrangement results in cancellation of base-emitter function biases, good thermal characteristics, and an output impedance of approximately 10 ohms. Note that because of the nonlinear load presented by the sine shaper to this driver, the waveform seen at A2TP10 will not be linear, but will show signs of increased loading toward the peaks; its peak-to-peak voltage will be about 3.8 volts, when the input triangle at A2TP7 is 6 volts peak-to-peak.

b. SINE SHAPER. - This section involves transistors A2Q38 through A2Q55. Emitter follower A2Q38 sets the positive voltage at the top of the resistive bias network A2RN1. This voltage is adjusted by means of pot A2R134. The foot of the ladder network is biased by means of emitter-follower A2Q39. Both A2Q38 and A2Q39 are npn transistors. so that any temperature changes will cause the top and foot of the ladder network to shift

together in voltage. This provides temperature compensation to all clamp emitter-followers biased by the ladder.

Transistors A2Q40 through A2Q46 do the clamping for the positive half-cycle of the waveform. Each base is biased to a voltage 0.6 volt lower than the desired clamping level. Resistors A2R139 through A2R144 form the loading network for the driving resistor A2R136.

The circuitry on the right side (A2Q47 to A2Q55) is a mirror image of the section just described, and performs the same function for the negative half of the cycle. The partly-shaped waveform can be observed at A2TP10. The peaks will still be pointed, however, because the peak cancellation transistors A2Q40 and A2Q47 operate on the waveform by means of the subtraction operation performed by the sine amplifier.

c. SINE AMPLIFIER. - The sine amplifier (consisting of transistors A2Q56 through A2Q60) is of similar design to the triangle amplifier and inverter amplifier. The sine amplifier, like the triangle amplifier, is configured in the potentiometric mode. Overall gain with feedback is nominally +1.57. At the input to the amplifier, filter components A2L1 and A2C58 attenuate noise and distortion at frequencies above 10 MHz. The peak of the triangle waveform is cancelled by a signal across A2R138, to the inverting input of the sine amplifier.

4-8. VARIABLE PULSE

The variable pulse circuits provide a means for obtaining an output pulse, variable between 5 percent and 95 percent duty cycle, at a repetition rate established by the frequency setting of the function generator. The variable pulse can also be modulated from an external ±10 volt source via the PWM input.

Figure 4-11 shows the method of developing the variable width pulse. At some variable point during the ramp cycle, the sum of the instantaneous ramp voltage and the d-c output of the pulse width control will be zero. This point can occur anywhere within the extremes of the ramp. The output pulse will be a rectangular wave, with transitions at the two points on the ramp where the summed voltages are equal to zero.

As shown on the detailed schematic, figure 7-3, comparator A2IC1 generates a positive-going pulse whenever the ramp voltage at A2R26 is more positive than the variable d-c level at A2R25. Feedback network A2R29 and A2R30 provides a small amount of positive feedback to ensure a clean transition. The comparator output is coupled to a current-mode driver A2Q6 and A2Q7. The output of A2Q7, clamped at ±5 volts, is buffered by a pair of complementary emitter follower drivers.

4-9. OUTPUT AMPLIFIER

The output amplifier operates as a (non inverting) potentiometric amplifier with inherently high input impedance. The attenuation obtained by the variable control is thereby essentially linear with rotation. The closed loop gain of the amplifier is nominally +5, which is adequate to ensure a 30-volt p-p output (open circuit) capability from internal signal sources.

A LO output is also provided, at a level 30 db below that of the HI output. This, together with over 30 db attenuation available from the level control, makes it possible to control the signal level over a range in excess

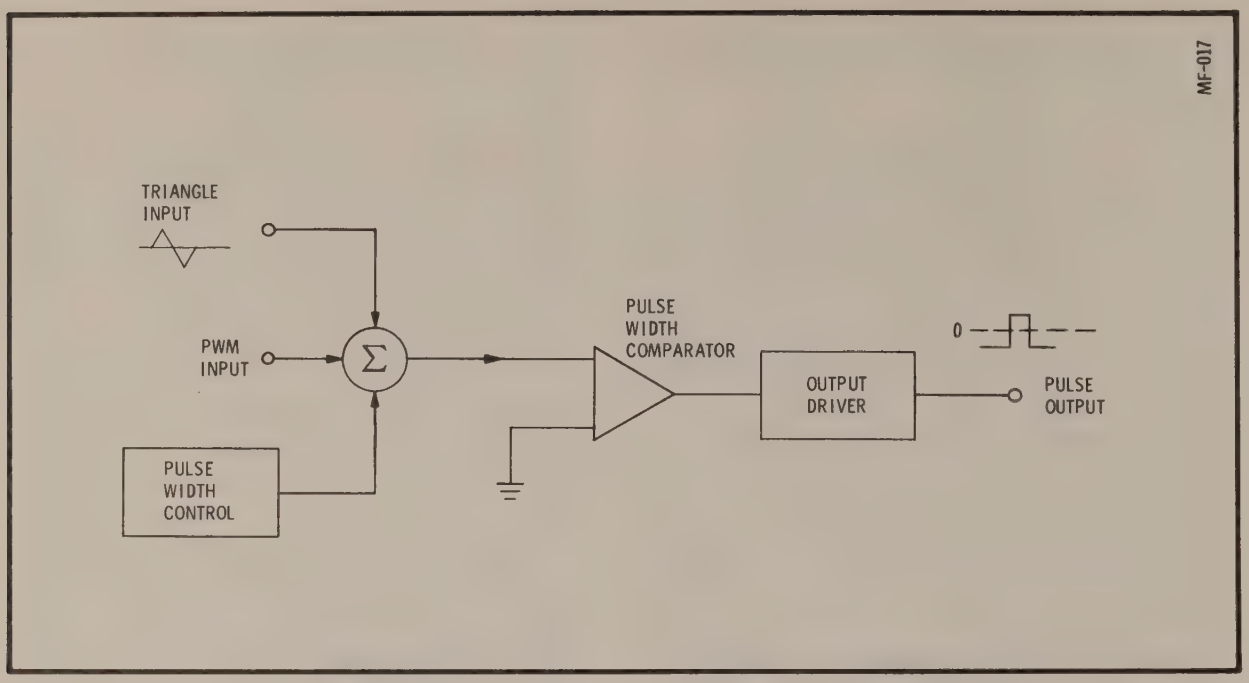


Figure 4-11. Variable Pulse Width, Block Diagram

of 60 db from the maximum level of 30 volts p-p.

The block diagram of figure 4-12 shows the essential components of the output amplifier and its controls. Note that four front panel controls are associated with its operation:

- WAVEFORM selector switch (A1S2-4)
- OFFSET switch (A1S1)
- ADJ (OFFSET) control (A2R1)
- OUTPUT LEVEL control (A2R8)

In the following detailed description, refer to figure 4-12 and the schematic diagram, figure 7-5.

a. WAVEFORM AND OFFSET SWITCHES.- The input signal that drives the output amplifier is derived from the wiper arm of the WAVEFORM switch A1S2-4, where one of eight possible waveforms may be selected. Each of these waveforms comes from a source whose equivalent circuit consists of a 6-volt p-p generator with an internal impedance of 50 ohms. The signal is fed to an offset network A2R2 through A2R7, then to the OFFSET switch A2S1-1. The offset network provides a nominal 6 db attenuation (one-half) of the selected signal, while also introducing fixed offsets for modes requiring a zero (ground) signal baseline.

The OFFSET switch adds either a fixed or adjustable offset to the selected waveform. Section A2S1-2 of the OFFSET switch provides for an adjustable offset voltage introduced into the amplifier. In this offset mode, it is possible to adjust offset and signal level (with offset voltage limited to nominally ±5.0 volts into 50 ohms). This adjustment is by means of the front panel control A2R1. This

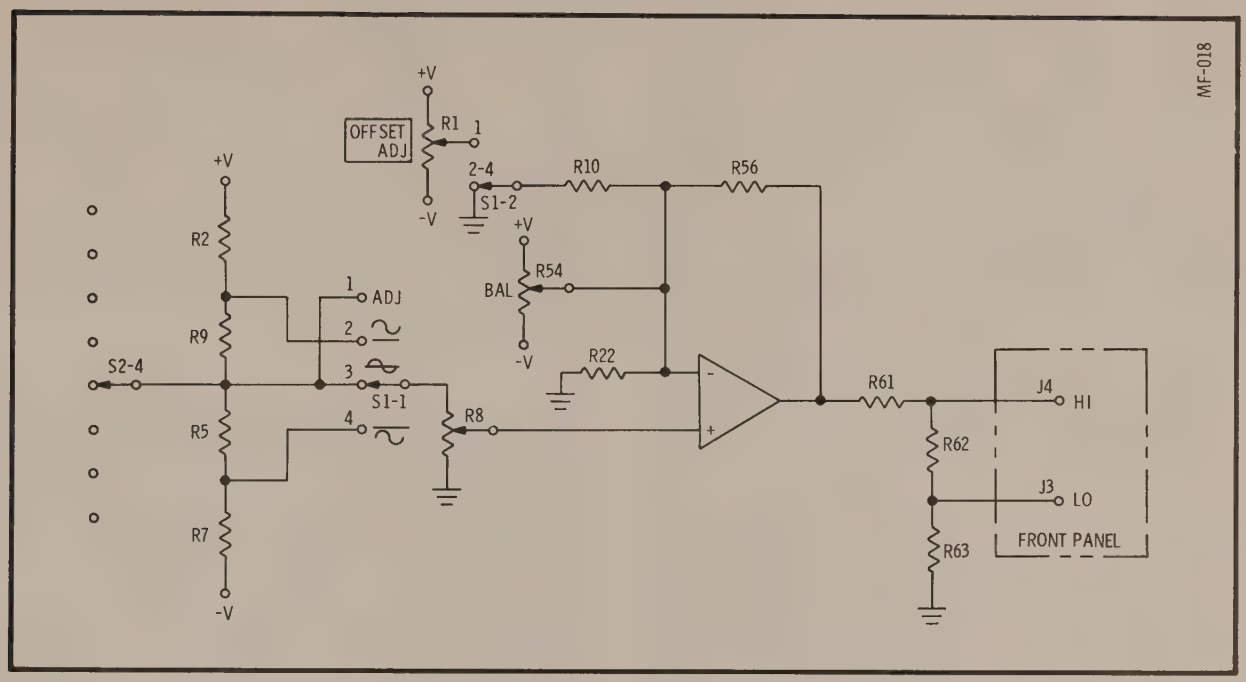


Figure 4-12. Output Amplifier, Block Diagram

baseline control is independent of the setting of the variable attenuator control.

b. OUTPUT AMPLIFIER. - The signal from the OUTPUT LEVEL is fed directly to input transistor A2Q1. Differential pair A2Q2 and A2Q3 is a common emitter pair amplifier with overall amplifier feedback applied to base of A2Q4. Transistors A2Q10 and A2Q13 serve as current sources to bias the common base output drivers A2Q11 and A2Q12. Current sources A2Q10 and A2Q13 are also driven at high frequencies through A2C3 and A2C4, thereby extending high frequency performance by an order of magnitude. Cascaded emitter followers A2Q14 through A2Q17 provide necessary power gain to supply the amplifier load.

At the output, the signal is routed to two BNC panel connectors. The HI output, through A2R61, will drive up to 15 volts p-p when terminated into a 50-ohm load. The unloaded maximum voltage is at least 30 volts p-p. At the LO output, the signal attenuated by A2R62 and A2R63 will have a p-p voltage 30 db below that of the terminated HI output. The output impedance at either output is 50 ohms.

4-10. POWER SUPPLY

Six regulated d-c power sources are required for the waveform generator circuits; these are ±5 volts, ±12 volts, and ±24 volts. These supplies are referenced to a single zener reference diode such that each voltage varies proportionally with the reference.

The power supply (figure 7-7) consists of four fullwave rectifiers for use with the plus and minus 12 volt and the plus and minus 24 volt regulators. The ±5 volt system loads are obtained from ±12 volt d-c regulated lines.

The raw dc is furnished by transformer A3T1, rectifier diodes A3CR1 through A3CR4, A3CR11 through A3CR14, and filter capacitors A3C1, A3C6, A3C17, and A3C18. When power is applied, the +12 voltage line begins to rise due to current supplied to A7 through Q8 and Q21. A reference voltage level is established at IC3 pin 5 by diode CR18 and zener diode CR14. The +12 voltage will continue to rise until IC3 pin 4 voltage is equal to that on pin 5, whereupon the +12 output voltage will hold at a level set by A3R29. Output filter capacitors A3C15 and A3C16 aid in reducing the output impedance of the regulator. A3Q9 is a current limit control. As more current is drawn through A3Q7, an increasing voltage appears across A3R19. When this voltage reaches approximately 0.7 volt dc, A3Q9 turns on, clamps A3Q7 base to A3Q7 emitter, and shunts the turn on current flowing through R21.

The -12-volt regulator operates identically to the +12-volt system except that the operating level is determined by current summation of A3R36 and A3R41 at point A3IC4 pin 4.

Plus and minus 24-volt regulating amplifiers A3IC1 and A3IC2 are powered directly from the +12-volt outputs. The -24-volt supply voltage is determined by the +12-volt level by summing resistors A3R16 and A3R15. The +24-volt supply is regulated through resistors A3R8 and A3R9. Circuit operation of the +24-volt system is identical to that described for the +12-volt supply.

Plus 5 volts is obtained from the +12-volt supply. Resistors A3R44 and A3R45 and diode A3CR24 establish 5.7 volts at the base of A3Q14. If the +5-volt output is low, A3Q14 emitter is low and A3Q14 will conduct. This causes A3Q13 to conduct, causing the +5-volt output to rise until A3Q14 begins to cut off. Capacitors A3C24 and A2C25 serve to reduce the +5-volt output impedance. Short-circuit protection for this supply is achieved by limiting base current to A3Q14 through A3R44.

Operation of the -5-volt supply is identical to the ±5-volt supply except that output power is derived from the -12-volt system.

Section V
CALIBRATION AND MAINTENANCE

5-1. INTRODUCTION

This section describes the procedures for proper maintenance and repair of the F51 Function Generator. Included are performance checks, calibration and adjustment information, and a troubleshooting guide. Periodic maintenance is not normally required. The overall stability and reliability of the instrument is such that, if used properly, it will provide years of uninterrupted service.

This section of the manual is divided into three basic areas: (1) performance verification, (2) calibration and adjustment, and (3) test point measurements and troubleshooting guide.

5-2. TEST EQUIPMENT REQUIRED

Table 5-1 lists the test equipment required to perform the procedures given in this section. The table includes the types of instruments required, their minimum specifications, and recommended models. If the recommended model is not available, any model which meets the minimum specifications may be substituted.

5-3. PERFORMANCE CHECKS

The following performance checks are designed to assist in comparing the F51A with its published specifications. These checks may be used for incoming inspection, periodic maintenance, and after-repair checks. The performance checks should be made before calibrating the instrument. If the instrument does not meet the requirements outlined in the performance checks, refer to the calibration procedure, paragraph 5-4, in this section.

Performance check data tables are provided throughout this section for recording the performance of the F51A during the performance checks. These tables may be duplicated and used to provide a permanent record if desired.

The performance check procedure consists of the following individual tests:

- Dial Accuracy Check
- Sinewave Distortion Check
- Waveform Symmetry Check
- Squarewave and Pulse Overshoot and Rise-Time Check
- Offset Control Check
- Output Terminal Loading Check
- Variable Pulse Width Check
- VCG Input Check
- Sync Input Check

Table 5-1. TEST EQUIPMENT REQUIRED

Type	Suggested Model	Minimum Specifications
Oscilloscope	Tektronix 454 w/P6047-10X probes Tektronix 585A with 1A5 plug-in on 81A adapter	DC to 100 MHz 0.1 v/cm vertical sensitivity Differential Comparator 50 MHz
Counter	HP 5326A	FREQ: 5 Hz to 10 MHz, 5 digits PERIOD: 1 ms to 3000 sec 4 digits TIME: INTERVAL: .1 μsec - 2000 sec
Digital Voltmeter	Fluke 8300A	DC: 1 mv to 25 v AC: 1 mv to 30 v
DC Voltage Source	Electronic Development Corp. MV100N	10v max, settable to 1 mv
Distortion Analyzer	HP 333A	Freq. Range: 5 Hz to 600 kHz, distortion introduced: <0.03 percent 5 Hz to 200 kHz <0.06 percent 200 kHz to 600 kHz
Spectrum Analyzer RF Voltmeter	HP 8553L/8552A Display 140S Boonton 91C	100 MHz 1 percent accuracy 100 kHz - 500 MHz 1 percent accuracy
Function Generator	IEC: Any SERIES 30, SERIES 50, or SERIES 50A function generator	2 MHz at 5v p-p sine and square waves
50-Ohm Termination	Tektronix 011-0049-01	Feedthrough, BNC
Lab Power Supply	-	Variable to 10v dc, 0.01 percent line and load regulation, 10 mv resolution

a. DIAL ACCURACY CHECK.

Step 1. Connect the HI terminal of the F51A to a counter through a 50-ohm feed-through terminal.

Step 2. Set WAVEFORM switch at ⊓ .

Step 3. Set frequency dial at the indicated values in table 5-2.

Step 4. Set MULTIPLIER at the values indicated in table 5-2.

Step 5. The counter should read within the limits specified in table 5-2 for each indicated frequency.

Step 6. Set WAVEFORM switch at ∧ .

Step 7. The counter should read within the limits specified in table 5-3.

b. SINEWAVE DISTORTION CHECK.

Step 1. Set the frequency dial to 10.

Step 2. Set the MULTIPLIER to 1 K.

Step 3. Set the WAVEFORM switch to ∿ .

Step 4. Connect the HI output terminal to the distortion analyzer using a 50-ohm coaxial cable.

Step 5. Terminate the cable with the 50-ohm feed-through termination.

Step 6. Set the OUTPUT LEVEL to 10 volts p-p using an oscilloscope.

Step 7. Set the analyzer controls to read the harmonic content of the 10-kHz signal. Harmonic distortion should be less than 0.5 percent.

Step 8. Make distortion measurements at the frequencies listed in table 5-4.

Step 9. The HP-333A distortion analyzer is useful only to 600 kHz. A spectrum analyzer should be used to check the harmonic content in the megahertz region.

NOTE

The spectrum analyzer input impedance is 50 ohms; therefore, the feed-through terminator should not be used with it. Also, be careful to keep the signal level into the instrument at less than 1 volt rms.

c. WAVEFORM SYMMETRY CHECK.

Step 1. Set the frequency to a value in each frequency range specified in table 5-5.

Step 2. Connect both inputs of the time interval counter to the F51A SYNC OUT terminal with a 50-ohm feed-through termination.

Step 3. Set channel A to +0.5 volt.

Step 4. Set channel B to -0.5 volt.

Step 5. Record time interval measurement in table 5-6.

Step 6. Set channel A to -0.5 volt.

Step 7. Set channel B to +0.5 volt.

Step 8. Record time interval measurement in table 5-6.

Step 9. The time measurements in steps 5 and 8 should be within the tolerance $(T_1 - T_2 / T_1 + T_2)$ specified in table 5-5.

TABLE 5-2. DIAL ACCURACY VERIFICATION

Dial	Multiplier	Counter Reading	
		Low Limit	High Limit
0.5	0.001	1653 sec	2532 sec
5	0.001	194 sec	206 sec
10	0.001	98 sec	102 sec
0.5	0.01	165 sec	253 sec
5	0.01	19.4 sec	20.6 sec
10	0.01	9.8 sec	10.2 sec
0.5	0.1	16.5 sec	25.3 sec
5	0.1	1.94 sec	2.06 sec
10	0.1	0.98 sec	1.02 sec
0.5	1	1.65 sec	2.53 sec
5	1	0.194 sec	0.206 sec
10	1	0.098 sec	0.102 sec
0.5	10	165 m sec	253 m sec
5	10	19.4 m sec	20.6 m sec
10	10	9.8 m sec	10.2 m sec
0.5	100	39.5 Hz	60.5 Hz
5	100	485 Hz	515 Hz
10	100	980 Hz	1020 Hz
0.5	1 K	395 Hz	605 Hz
5	1 K	4.85 kHz	5.15 kHz
10	1 K	9.8 kHz	10.2 kHz
0.5	10 K	3.95 kHz	6.05 kHz
5	10 K	48.5 kHz	51.5 kHz
10	10 K	98 kHz	102 kHz
0.5	100 K	39.5 kHz	60.5 kHz
5	100 K	485 kHz	515 kHz
10	100 K	950 kHz	1050 kHz
0.5	1 M	285 kHz	715 kHz
5	1 M	4.65 MHz	5.35 MHz
10	1 M	9.2 MHz	10.8 MHz

TABLE 5-3. DIAL ACCURACY FOR RAMP AND PULSE WAVEFORMS

Dial	Multiplier	Counter Reading	
		Low Limit	High Limit
0.5	100 K	39.5 kHz	60.5 kHz
5	100 K	485 kHz	515 kHz
10	100 K	890 kHz	1110 kHz
0.5	1 M	350 kHz	650 kHz
5	1 M	4.4 MHz	5.6 MHz

TABLE 5-4. SINEWAVE DISTORTION

Frequency	Measured Distortion	Allowable Distortion
0.0005 Hz to 100 kHz		< 0.5 percent (-46 db)
100 kHz to 1 MHz		< 1 percent (-40 db)
1 MHz to 5 MHz		< 3 percent (-30 db)
5 MHz to 11 MHz		< 5 percent (-25 db)

TABLE 5-5. WAVEFORM SYMMETRY

Frequency	Positive Slope (t_1)	Negative Slope (t_2)	Allowable Tolerance	Actual Deviation $\frac{t_1-t_2}{t_1+t_2}(100)$
0.0005 Hz to 10 Hz			1.0 percent	
10 Hz to 100 kHz			0.5 percent	
100 kHz to 3 MHz			2.0 percent	
3 MHz to 11 MHz			5 percent	

d. SQUAREWAVE, PULSE OVERSHOOT, AND RISE-TIME CHECK.

Step 1. Set the frequency to 1 MHz.

Step 2. Set the OFFSET switch to .

Step 3. Set the WAVEFORM switch to .

Step 4. Connect a scope to the HI output terminal by means of a 50-ohm coaxial cable and 50-ohm feed-through terminator.

Step 5. Set the OUTPUT LEVEL control to 10 volts p-p.

Step 6. Observe the 10 volt p-p waveform for rise time and overshoot. Rise and fall times should not exceed 30 nsec.

Step 7. The overshoot should be less than 0.5 volt.

Step 8. Set the WAVEFORM switch to and repeat steps 4 and 7.

e. OFFSET CONTROL CHECK.

Step 1. Set the frequency to 1 kHz.

Step 2. Set the WAVEFORM switch to .

Step 3. Set the OFFSET switch to .

Step 4. Connect the HI output of the F51 to the oscilloscope using the 50-ohm termination.

Step 5. Adjust the OUTPUT LEVEL control to obtain a scope display of 10 volts p-p using the DC input setting.

Step 6. Turn the OFFSET switch to the position.

Step 7. The waveform should now appear at half amplitude, with its positive peaks at the zero voltage level.

Step 8. Rotate the OFFSET switch to the position and verify that the negative peaks of the waveform are at the zero voltage level.

f. OUTPUT TERMINAL LOADING CHECK.

Step 1. Set the frequency to 1 kHz.

Step 2. Set the WAVEFORM switch to .

Step 3. Set the OFFSET switch to .

Step 4. Connect a scope to the HI output terminal.

Step 5. Set the OUTPUT LEVEL control for an output of 30 volts p-p.

Step 6. Connect the scope to the LO output terminal.

Step 7. Observe a 1-volt p-p waveform.

Step 8. Connect a 50-ohm feed-through load to the scope.

Step 9. Observe 15 volts p-p on HI and 0.5 volt p-p on the LO terminal.

g. VARIABLE PULSE WIDTH CHECK.

Step 1. Set the frequency dial to 10.0.

Step 2. Set the OFFSET switch to .

Step 3. Set the WAVEFORM switch to (VAR PULSE).

Step 4. Set the MULTIPLIER switch to 100.

Step 5. Connect channel A of a dual trace scope to the HI output terminal.

Step 6. Connect channel B to SYNC OUT.

Step 7. Rotate the VAR PULSE (⎍) width control between its extreme positions.

Step 8. Observe waveform having a duty cycle variable from at least 10 percent to 90 percent of the 1-ms period of the waveform.

Step 9. Set the MULTIPLIER switch to 100K.

Step 10. Vary the setting of the VAR PULSE control and observe that the minimum pulse width is 100 ns or less, measured at half amplitude.

Step 11. Rotate the VAR PULSE control to the other end and observe that the minimum pulse width is 100 ns or less.

Step 12. Set the MULTIPLIER switch to 1 M.

Step 13. Set the frequency dial to 5.

Step 14. Connect an oscilloscope through a 50-ohm terminal and observe the variable pulse.

Step 15. The minimum voltage amplitude should be 12 volts p-p.

h. VGC INPUT CHECK.

Step 1. Set the frequency dial at its lower stop.

Step 2. Set the MULTIPLIER switch to 100.

Step 3. Connect a +10 volt voltage source to the VCG INPUT.

Step 4. Connect a frequency counter to the SYNC OUT terminal.

Step 5. Connect a digital voltmeter to the VCG INPUT.

Step 6. A voltage of +10.0 ±0.7 volts should be applied for a frequency of 1.000 kHz.

i. SYNC INPUT CHECK.

Step 1. Connect a function generator to the F51A SYNC IN terminal, the sync input of an oscilloscope, and to one channel of the oscilloscope.

Step 2. Connect the other channel of the oscilloscope to the HI terminal of the F51A.

Step 3. Adjust the external function generator to produce squarewaves at 1 kHz with a peak-to-peak amplitude of 5 volts.

Step 4. Set the F51A MULTIPLIER switch to 1 K; set the WAVEFORM switch to ⊓.

Step 5. Vary the F51A frequency dial back and forth though 1.0 and observe occurrence of sync lock on the oscilloscope.

Step 6. Set the external generator and the F51A for a frequency of 1 MHz and repeat step 5.

5-4. ADJUSTMENT AND CALIBRATION PROCEDURE

The following paragraphs contain a complete adjustment and calibration procedure for the function generator. This procedure should be performed only if it has been determined by the performance checks (paragraph 5-3) that the instrument is not operating within the published specifications. Voltage measurements are referenced to chassis ground. Adjustment locations are shown in figure 5-2 and test point locations in figure 5-3.

The detailed calibration procedures should be performed in the following order:

- Power Supply Calibration
- Dial Calibration
- Waveform Symmetry Calibration
- Triangle Amplitude Calibration
- Triangle Amplifier Gain Calibration
- Inverter DC Balance Calibration
- Hi-Frequency Ramp Calibration
- Frequency Calibration
- Output Amplifier Calibration
- Offset Calibration
- Sine Shaper Calibration

a. POWER SUPPLY CALIBRATION.

Step 1. Connect a digital voltmeter and oscilloscope to A3TP5 and A3TP6 (ground).

Step 2. Adjust potentiometer A3R29 until the voltmeter indicates +12.00 volts ±5.0 mv.

Step 3. The ripple waveform should be less than 10 mv p-p.

Step 4. Using the digital voltmeter and oscilloscope, measure the voltages at the test points listed in table 5-6.

Step 5. If any of the voltage measurements are out of tolerance, correct the trouble before continuing with the calibration procedure.

b. DIAL CALIBRATION.

Step 1. Set potentiometer A1R2 at midrange position.

Step 2. Set the frequency dial fully clockwise where cursor indicator lines up with the 1 portion of the 0.1 dial mark.

Step 3. Connect the digital voltmeter between A1TP1 and ground, A1TP21.

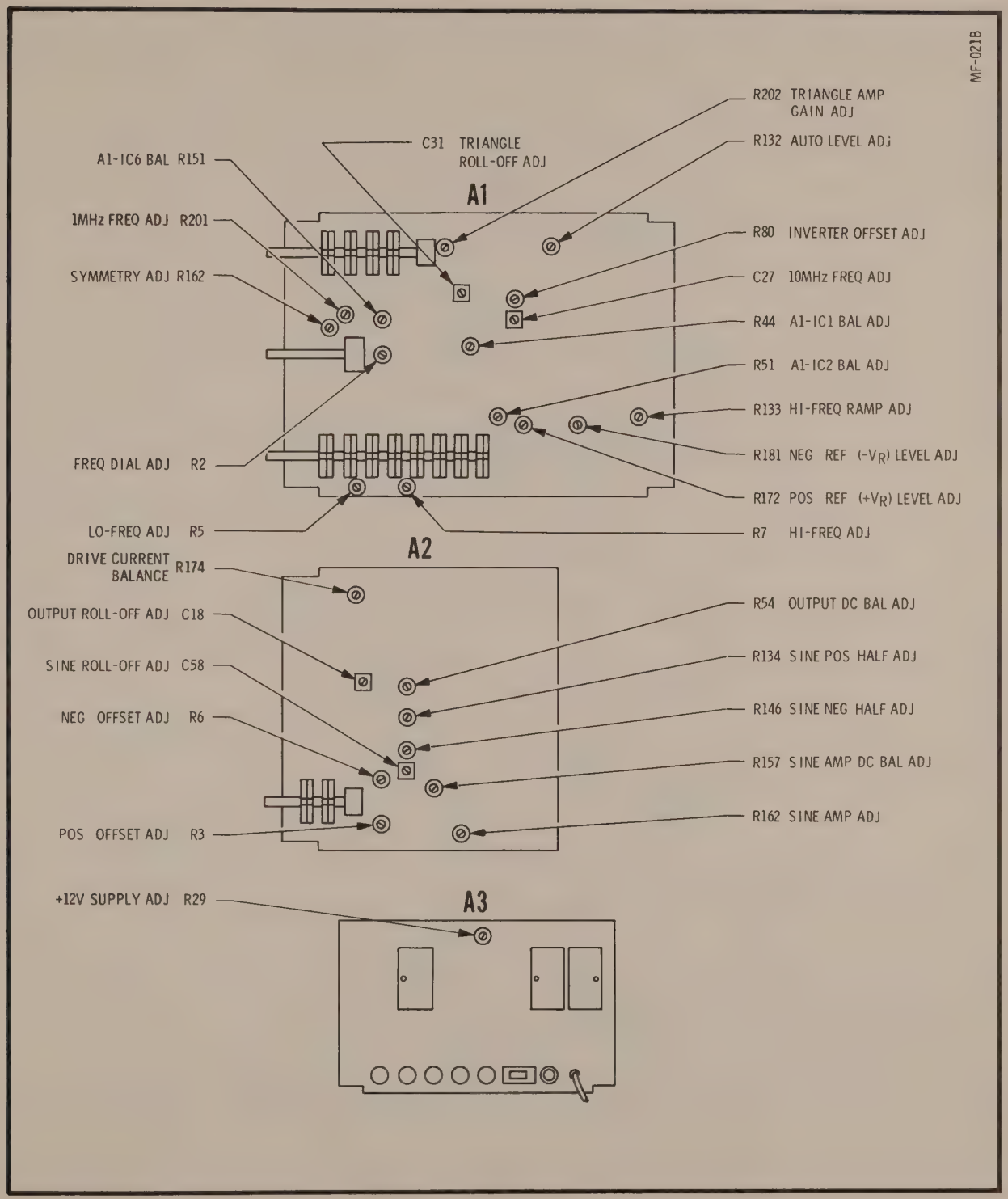


Figure 5-1. Adjustment Locations

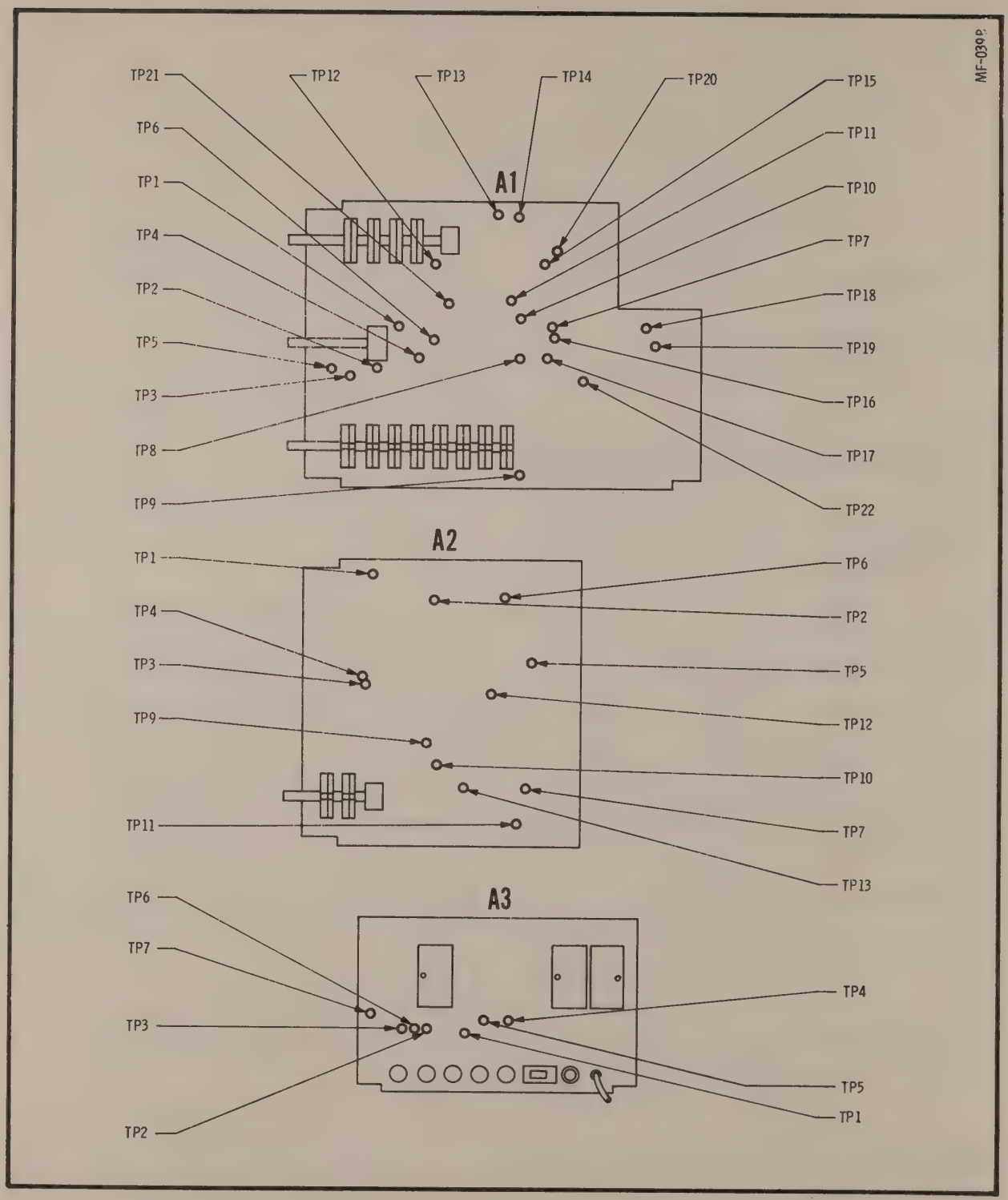


Figure 5-2. Test Point Locations

TABLE 5-6. POWER SUPPLY VOLTAGES

Test Point	Voltage	Max Ripple (millivolts) Volts p-p
A3-TP5	+12.00 ± 0.01 volts	10
A3-TP7	-12.00 ± 0.06 volts	10
A3-TP1	+24.00 ± 0.12 volts	20
A3-TP4	-24.00 ± 0.12 volts	20
A3-TP2	+5.00 ± 0.3 volts	5
A3-TP3	-5.00 ± 0.3 volts	5

Step 5. Slowly turn the frequency dial clockwise while observing that the voltmeter indicates a voltage decreasing linearly to less than 120 mv. (The body of A1R4 may require rotating to obtain less than 120 mv.)

Step 6. With the frequency dial set at 0.1, adjust the body of potentiometer A1R4 until the voltmeter indicates 145 ±5 mv.

Step 7. Holding the body of potentiometer A1R4 (step 6), secure the hexagon nut on A1R4.

Step 8. If step 6 is out of the acceptable limits, repeat steps 1 through 7.

c. WAVEFORM SYMMETRY CALIBRATION.

Step 1. Connect the digital voltmeter between A1TP5 and A1TP3.

Step 2. Adjust potentiometer A1R151 until the voltmeter indicates +0.050 volt ±5 mv.

Step 3. Set the MULTIPLIER switch to 100.

Step 4. Set the frequency dial to 5.

Step 5. Connect a floating digital voltmeter between A1TP8 and A1TP3.

Step 6. Record the voltmeter reading.

Step 7. Reconnect the voltmeter between A1TP6 and A1TP2.

Step 8. Adjust potentiometer A1R162 to obtain a voltmeter indication equal to previous reading within +2 mv.

Step 9. Connect a floating digital voltmeter between A1TP4 and A1TP6.

Step 10. Adjust potentiometer A1R44 until an indication of 0.000 volt ±1 mv is obtained.

Step 11. Disconnect the voltmeter (step 9) and reconnect it between A1TP5 and A1TP8.

Step 12. Adjust potentiometer A1R51 until an indication of 0.000 volt ±1 mv is obtained.

d. TRIANGLE AMP GAIN CALIBRATION.

Step 1. Set the unit frequency dial to 10.

Step 2. Set the MULTIPLIER switch to 100.

Step 3. Connect an oscilloscope with 1A5 plug-in to A1TP11 and A1TP9 (ground) and record the amplitude of the triangle waveform.

Step 4. Connect the oscilloscope to A1TP14.

Step 5. Adjust A1R202 to obtain four times the amplitude of step 3 to within ±1 percent.

e. TRIANGLE AMPLITUDE CALIBRATION.

Step 1. Set the MULTIPLIER switch to 100.

Step 2. Set the frequency dial to 10.

Step 3. Set potentiometer A1R133 to its mid-range position.

Step 4. Set the WAVEFORM switch to ⩘ .

Step 5. Connect a digital voltmeter to A1TP17 and A1TP9 ground.

Step 6. Adjust potentiometer A1R172 to obtain an indication on the voltmeter of +2.700 ±0.005 volts.

Step 7. Connect the digital voltmeter to A1-TP18 and A1TP9 (ground).

Step 8. Adjust potentiometer A1R181 to obtain an indication on the voltmeter of -2.700 ±0.005 volts.

Step 9. Set the MULTIPLIER switch to 1 M.

Step 10. Set the frequency dial to 3.

Step 11. Connect an oscilloscope with a 1A5 plug-in unit to A1TP14 and A1TP9 (ground).

Step 12. Adjust A1R132 until the triangular waveform negative peak is -3.000 ±0.010 volts.

f. INVERTER DC BALANCE CALIBRATION.

Step 1. Set the WAVEFORM switch to ⎍ .

Step 2. Connect the digital voltmeter between A1TP13 and A1TP9 (ground).

Step 3. Adjust potentiometer A1R80 until the voltmeter indicates 0.00 ±0.01 volts.

g. HI FREQ RAMP CALIBRATION.

Step 1. Set the OFFSET switch to ⩛ .

Step 2. Set WAVEFORM switch to ⩘ .

Step 3. Set the frequency to 3.0 MHz.

Step 4. Connect an oscilloscope to A1TP14.

Step 5. Adjust A1C31 for minimum aberrations. (If time jitter appears, adjust A1R133 to stabilize the waveform.)

h. FREQUENCY CALIBRATION.

Step 1. Set the WAVEFORM switch to ∿ .

Step 2. Connect a counter to the SYNC OUT terminal.

Step 3. Set the frequency dial to 10.

Step 4. Set the MULTIPLIER switch to 100.

Step 5. Set the OFFSET switch to ⩛ .

Step 6. Adjust A1R2 for a frequency of 1000 ±1 Hz.

Step 7. Recheck at frequency dial setting of 0.5, observing a frequency reading of 50 ±5 Hz.

Step 8. Rotate the frequency dial clockwise to its lower stop.

Step 9. Record the frequency indicated on the counter (< 1 Hz).

Step 10. If steps 7 and 9 are not within the tolerance, repeat the procedure from the dial calibration section.

Step 11. Set the frequency dial to 8.

Step 12. Set the MULTIPLIER switch to 0.1.

Step 13. Adjust A1R5 for a period of 1.250 +0.005 seconds.

Step 14. Set the MULTIPLIER switch to 1K.

Step 15. Adjust A1R7 for a frequency of 8000 ±5 Hz.

Step 16. Set the MULTIPLIER switch to 10K.

Step 17. Verify that the frequency is 80k ±400 Hz.

Step 18. If step 17 is not satisfactory, re-adjust potentiometer A1R7 and repeat steps 14 to 17.

Step 19. Set the MULTIPLIER switch to 1 M.

Step 20. Set the frequency dial to 8.

Step 21. Adjust trimmer A1C27 for an 8.0 MHz indication on the counter.

Step 22. Set the frequency dial to 10.0.

Step 23. Set the MULTIPLIER switch to 1M.

Step 24. Adjust trimmer capacitor A1C31 for a frequency of 10.0 ±0.3 MHz. (Note: This may influence ramp waveform. Recheck Step 5 of Hi Freq Ramp Calibration procedure and optimize with this step. If frequency instability appears, adjust A1R133.)

Step 25. Set frequency dial to 2.0 MHz.

Step 26. Adjust A1R132 for a frequency of 2 MHz ±100 kHz.

Step 27. Set the MULTIPLIER switch to 100K.

Step 28. Adjust A1R201 for a frequency of 800 ±4 kHz.

Step 29. Repeat steps 19 through 28 until dial settings are within tolerance.

i. OUTPUT AMPLIFIER CALIBRATION.

Step 1. Set the OFFSET switch to ∿ .

Step 2. Set the frequency dial to 10.0.

Step 3. Set the MULTIPLIER switch to 1K.

Step 4. Set the WAVEFORM switch to VAR ⎍ .

Step 5. Connect a short jumper between A2TP1 and A2TP2 (ground).

Step 6. Connect the digital voltmeter to A2TP3 and A2TP2.

Step 7. Adjust A2R54 until the voltmeter reads 0 ±0.01 volts.

Step 8. Remove the jumper (step 5).

Step 9. Set the WAVEFORM switch to ⎍ .

Step 10. Set the MULTIPLIER switch to 100K.

Step 11. Set the frequency dial to 10.

Step 12. Connect the HI output to the oscilloscope input by means of a 50-ohm coaxial cable. (Use the 50-ohm feed-through termination adapter at the oscilloscope end of the cable.)

Step 13. Set the OUTPUT LEVEL control to 15 volts p-p on the oscilloscope at HI output.

Step 14. Observe the waveform for rise-time and overshoot. Rise and fall times (10 percent to 90 percent points) should not exceed 30 nsec and the overshoot should be less than 750 mv.

Step 15. Adjust A2C18 until both these conditions are met.

j. OFFSET CALIBRATION.

Step 1. Set the frequency to 100 Hz.

Step 2. Set the WAVEFORM switch to ⊓.

Step 3. Set the OFFSET switch to ⊸ .

Step 4. Connect the HI output of the function generator to the oscilloscope using the 1A5 plug-in. (Use the 50-ohm termination at the oscilloscope input.)

Step 5. Adjust the OUTPUT LEVEL control to obtain an oscilloscope display of 10 volts p-p.

Step 6. Turn the OFFSET switch to the ∿ position.

Step 7. The waveform should now appear at approximately half amplitude, with its positive peaks at the zero voltage level ±50 mv.

Step 8. Adjust A2R6 to obtain this condition.

Step 9. Rotate the OFFSET switch to the ⊸ position.

Step 10. Adjust A2R3 so that the negative peaks of waveform are 0 volts ±50 mv.

k. SINE SHAPER CALIBRATION.

Step 1. Set the frequency dial at 5.

Step 2. Set the MULTIPLIER switch at 10K.

Step 3. Set the WAVEFORM switch to ∿ .

Step 4. Set the OFFSET switch to ⊸ .

Step 5. Connect a short jumper lead between A2TP10 and A2TP13 (ground).

Step 6. Connect a short jumper lead between A2TP7 and A2TP13.

Step 7. Connect the digital voltmeter between A2TP11 and A2TP2 (ground).

Step 8. Adjust A2R157 for 0 volts ±10 mv at A2TP11.

Step 9. Remove jumper leads on A2TP10 and A2TP7.

Step 10. Connect an oscilloscope to the LO output terminal of the function generator.

Step 11. Set the OUTPUT LEVEL control at the LO terminal for 0.2 volt p-p (50-ohm load).

Step 12. Connect a distortion analyzer or spectrum analyzer to the LO output terminal.

Step 13. Alternately adjust A2R134 and A2R146 for minimum total distortion.

Step 14. Connect the oscilloscope to A2TP11.

Step 15. Using the comparator 1A5 plug-in, adjust A2R162 for a positive peak amplitude of +3.000 volts ±15 mv.

Step 16. Remove the oscilloscope from A2-TP11 and connect a high frequency voltmeter.

Step 17. Set the MULTIPLIER switch to 1M.

Step 18. Rotate the frequency dial from 5 to 11.

Step 19. Adjust A2C58 for a flat response over the range of step 18 of 2.08 vrms ±60 mv.

Step 20. Reconnect the HI output to a high frequency voltmeter.

Step 21. Set the frequency dial at 7.

Step 22. Measure and record the rms value.

Step 23. Rotate the frequency dial from 5 to 11.

Step 24. Adjust A2C18 if necessary to maintain a flat response of step 22 to within ±50 mv.

Step 25. Set the WAVEFORM switch to ⊓⊔.

Step 26. Set the frequency dial to 10.

Step 27. Set the MULTIPLIER switch to 100K.

Step 28. Set the OUTPUT LEVEL control to provide 10 volts p-p on the oscilloscope at HI output.

Step 29. Observe the waveform for rise-time and overshoot. Rise and fall times (10 percent to 90 percent points) should not exceed 30 nsec and the overshoot should be less than 0.5 volt.

5-5. TROUBLESHOOTING

The following paragraphs cover most of the individual circuits and are intended to help in the quick repair of the F51A. Refer to the functional block diagram, figure 7-1, and circuit schematics, figures 7-3, 7-5, and 7-7. An illustrative table containing all of the test-point measurements is also included. The following topics are covered in this section:

- Power Supply
- Voltage Level Sensor and Automatic Level Control
- Triangle Amplifier
- Inverter Amplifier.
- Frequency Control and Voltage-to-Current Converter
- Variable Pulse Width Shaper
- Test-Point Measurements

a. POWER SUPPLY TROUBLESHOOTING.- When the power supply is turned on, d-c voltages are established in sequence. The +12 volt supply starts first and provides a reference for the -12 volt supply and a power source for the +5 volt regulator. When the -12 volt output is established, a power source for the -5 volt regulator is provided. Presence of +12 volts powers the 24-volt regulator amplifiers, and the -24 volt supply will start, followed by the +24 volt supply. Thus, if +12 volt power is not present, no other voltages can be present. If -12 volt is missing, +24, -24, and -5 will be missing. If -24 volts is not operating, +24 will not operate. The only voltages which do not affect the operation of other voltage regulators are +5 and +24 volts.

In the case of incorrect voltages, the sequence to be followed is +12, -12, +5, -5, -24, and +24. If one or more voltages are incorrect, proceed as follows:

Step 1. Check the pilot lamp for presence of line power and fuse.

Step 2. Check for presence of d-c voltages according to the sequence listed.

Step 3. Check for a possible short or overcurrent on the affected supply. A3Q3, A3Q4, A3Q9, and A3Q10 provide current limiting which reduces the 12 and 24-volt lines to zero when overloads are present. The 5-volt regulators are self-limiting.

Step 4. If low voltages are present in the 12- or 24-volt systems and no overload currents are present, proceed as follows:

(a) Check overload transistors A3Q3, A3Q4, A3Q9, and A3Q10 for leakage or shorts.

(b) Check pass transistors A3Q1, A3Q6, A3Q7, and A3Q12 for open emitters. This condition is evident if the base of the pass transistor is >0.6 above its emitter.

Step 5. If high voltages are present in the 12 or 24-volt systems, check pass transistors A3Q1, A3Q6, A3Q7, and A3Q12 for shorts.

Step 6. When overvoltage is present in the 5-volt system, check pass transistors A3Q13 and A3Q16 for shorts. Undervoltage can be caused by an open A3Q13, A3Q14, A3Q15, or A3Q16.

b. VOLTAGE LEVEL SENSOR AND AUTOMATIC LEVEL CONTROL TROUBLESHOOTING. - The most likely cause of abnormal operation is within the VLS, because of its critical speed requirements. Obvious component failure should always be investigated initially, which might typically lead to one of the following:

(1) Improper reference voltages V_R (+) or V_R (-).

(2) Improper clamp voltage +3 or -3 volts.

(3) Incorrect d-c condition in ALC.

(4) Incorrect currents delivered to tunnel diodes.

(5) Failure of the latch circuit to toggle.

If no obvious component failures can be found, waveforms at A1TP16 and A1TP19 give the best clues as to causes of improper operation. A1TP16, at a d-c level of +12 volts, should exhibit a nominal 1-volt negative pulse at the positive triangle peak, and a nominal 3-volt positive pulse at the negative triangle peak.

The waveform at A1TP19 is at approximately +12.5 volts during the positive going ramp, and at approximately +11.7 volts during the negative going ramp. At the negative peak, a short duration pulse of +11.3 volts is normally present. Refer to test point waveforms, table 5-8.

c. TRIANGLE AMPLIFIER TROUBLE - SHOOTING. - In the event of major difficulty within the triangle amplifier, the main integrator will probably also be inoperative. In

this event, ground A1TP10 then check for correct d-c conditions within the amplifier circuit. Because of the straightforward circuitry, a stage-by-stage d-c check should give adequate clues.

d. INVERTER AMPLIFIER TROUBLESHOOTING. - Similar procedures can be followed for inverter amplifier troubleshooting, because of the similarity of its design. In the case of the inverter, a main loop signal may be available to assist in the event that the triangle amplifier is still operative. If this is the case, simply set the WAVEFORM switch to either a positive-going ramp (◿) or a pulse (⎍) to obtain the test signal.

e. FREQUENCY CONTROL AND VOLTAGE-TO-CURRENT CONVERTER TROUBLESHOOTING. - Because the prime function of the frequency control and voltage-to-current converter is to generate known currents, the first item to check should be current level. This is best accomplished by connecting a low impedance milliameter (or microameter) between A1TP10 and ground. This action will stall the integrator loop and make d-c measurements possible. The polarity of this current should be the same as the polarity of the voltage present at A1TP7. Table 5-7 lists the maximum current generated on each range, for 50/50 duty cycle functions (Frequency dial at 10).

(1) Following a determination of incorrect current levels, and whether or not they are a function of A1TP7 polarity, there should now be some clues as to the source of the problem. Note that in order to obtain a desired polarity at A1TP7, it may be necessary to force the voltage level sensor circuitry into the desired state. This can be accomplished by momentarily clipping a grounded 470-ohm resistor to either A1TP16 or A1TP19.

TABLE 5-7. INTEGRATOR CURRENT AT 50/50 DUTY CYCLE VERSUS FREQUENCY MULTIPLIER SETTING

Multiplier	Maximum Current
0.001	300 na
0.01	3 μa
0.1	30 μa
1	3 μa
10	30 μa
100	300 μa
1 K	30 μa
10 K	300 μa
100 K	1.5 ma
1 M	7.5 ma

(a) If proper current levels exist for negative polarity, the problem can be isolated to the area of A1IC6, A1IC2, A1S1-5, A1S1-3.

(b) If neither polarity at A1TP7 causes the proper current flow, this points to possible problems with A1IC6 circuitry.

(2) In the event of less obvious problems, such as poor waveforms at low frequencies, one should suspect excessive leakage current at the integrator. Low frequency operation requires total leakage in the nanoamp region, and any of several components should be suspected, as should the possibility of grease, dirt, or moisture on the circuit board itself.

f. VARIABLE PULSE WIDTH SHAPER TROUBLESHOOTING. - Verify the presence of a 6-volt p-p triangular waveform at the input to A2R26. Provided the waveform does exist, a nominal 0 to ±4-volt pulse should then be present at A2TP5. The presence of this pulse verifies the operation of comparator A2IC1.

Further signal tracing through the discrete driver circuits A2Q6 through A2Q9 should lead to the source of difficulty.

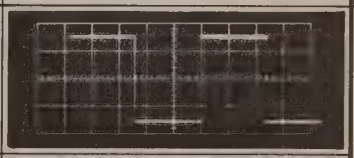
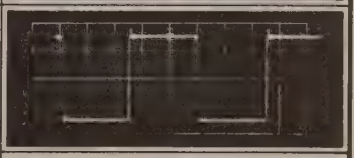
g. TEST POINT WAVEFORMS TROUBLESHOOTING. - Table 5-8 lists the d-c voltages or signal waveforms at each test point. The test point conditions are as follows unless specified otherwise:

INITIAL CONDITIONS

(1) Frequency Dial = 10
(2) MULTIPLIER = 100
(3) OUTPUT LEVEL = MAX CW
(4) WAVEFORM = ∿
(5) OFFSET = ⏦

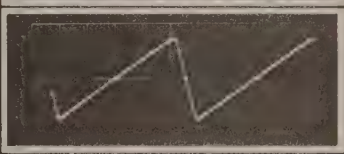
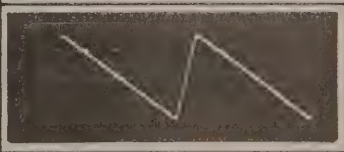
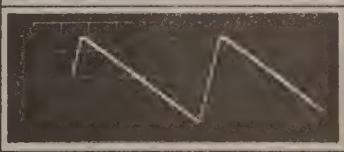
All measurements are made with respect to ground.

TABLE 5-8. TEST POINT MEASUREMENTS

Test Point	Conditions	Comments	Nominal Measurement
A1TP1 (Freq control)	Note (1)	Read dc	+10 volts
A1TP2 (V_A)	Note (1)	Read dc	+17.5 volts
A1TP3 (V_B)	Note (1)	Read dc	-17.5 volts
A1TP4 (V_C)	Note (1)	Read dc	+7.5 volts
A1TP5 (V_D)	Note (1)	Read dc	-7.5 volts
A1TP6 (Positive Current Source)	Note (1)	Read dc	+7.5 volts
A1TP7 (VLS Output)	Note (1)	H = 0.2 ms/cm V = 2 v/cm +0.7 vdc level	
	Note (2) MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 2 v/cm +0.7 vdc level	
A1TP8 (negative current source)	Note (1)	Read dc	-7.5 volts

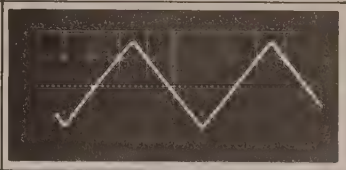
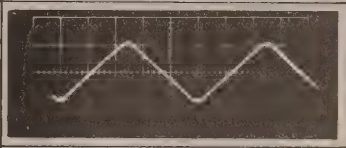
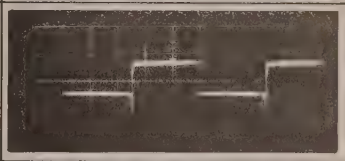
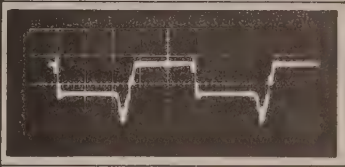
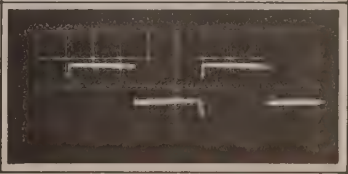
(1) See conditions specified in paragraph 5-5g.
(2) Conditions specified in paragraph 5-5g, except as noted.

Table 5-8. Test Point measurements (Continued)

Test Point	Conditions	Comments	Nominal Measurement
A1TP9 (Gnd)	None	None	0 volts
A1TP10 (Triangle Generator)	Note (1)	H = 0.2 ms/cm V = 0.5 v/cm	
	Note (2) MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 0.5 v/cm	
A1TP11	(Same as A1TP10)		
A1TP12 (Inverter Input)	Note (2) WAVEFORM ⌐‾	H = 0.2 ms/cm V = 2 v/cm	
	Note (2) WAVEFORM ⌐‾ MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 2 v/cm	
A1TP13 (Inverter Output)	Note (2) WAVEFORM ⌐‾	H = 0.2 ms/cm V = 2 v/cm	
	Note (2) WAVEFORM ⌐‾ MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 2 v/cm	
A1TP14 (Triangle Amplifier Output)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	

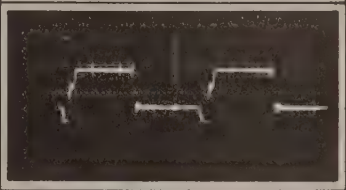
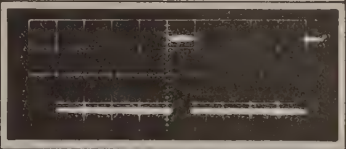
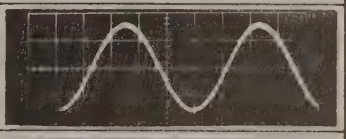
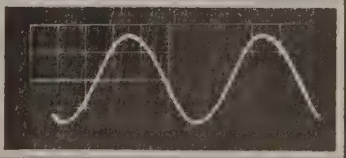
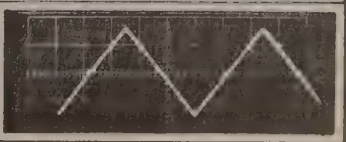
(1) See conditions specified in paragraph 5-5g.
(2) Conditions specified in paragraph 5-5g, except as noted.

Table 5-8. Test Point Measurements (Continued)

Test Point	Conditions	Comments	Nominal Measurement
A1TP14 (Triangle Amplifier Output)	Note (2) MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 2 v/cm	
A1TP15 (ALC Input)	Note (2) MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 2 v/cm	
A1TP16 (Tunnel Diode Triggering)	Note (1)	H = 0.2 ms/cm V = 0.5 v/cm +12 Volt Level	
	Note (2) MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V - 0.5 v/cm +12 Volt Level	
A1TP17 ($+V_{Ref}$)	MULTIPLIER 100	Read dc	+3 volts
	MULTIPLIER 100K	Read dc	+2 volts
	MULTIPLIER 1M	Read dc	0 volts
A1TP18 ($-V_{Ref}$)	MULTIPLIER 100	Read dc	-3 volts
	MULTIPLIER 100K	Read dc	-2 volts
	MULTIPLIER 1M	Read dc	0 volts
A1TP19 (Tunnel Diode Triggering)	Note (1)	H = 0.2 ms/cm V = 0.5 v/cm +12 Volt Level	

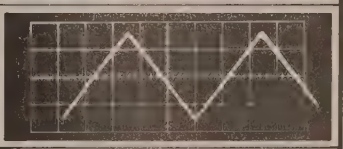
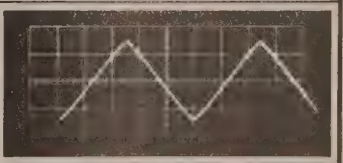
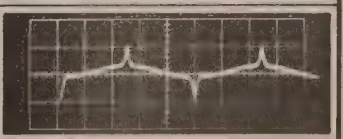
(1) See conditions specified in paragraph 5-5g.
(2) Conditions specified in paragraph 5-5g, except as noted.

Table 5-8. Test Point Measurements (Continued)

Test Point	Conditions	Comments	Nominal Measurement
A1TP19 (Tunnel Diode Triggering)	MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 0.5 v/cm +12 Volt Level	
A1TP20 (Ground)	None	None	0 volts
A1TP21 (Ground)	None	None	0 volts
A2TP1 (Output Amplifier Input)	Note (2) WAVEFORM ⎍	H = 0.2 ms/cm V = 2 v/cm	
	Note (2) WAVEFORM ⎍ MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 2 v/cm	
A2TP2 (Ground)	None	None	0 volts
A2TP3 (Output Amplifier Output)	Note (2) WAVEFORM ∿	H = 0.2 ms/cm V = 10 v/cm	
	Note (2) WAVEFORM ∿ MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 10 v/cm	
	Note (1)	H = 0.2ms/cm V = 10 v/cm	

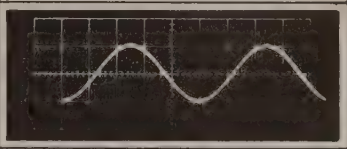
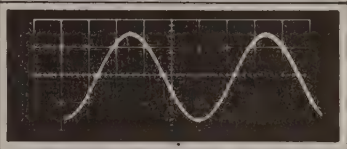
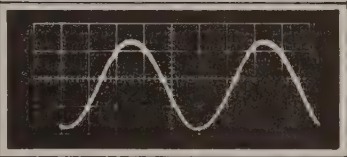
(1) See conditions specified in paragraph 5-5g.
(2) Conditions specified in paragraph 5-5g, except as noted.

Table 5-8. Test Point Measurements (Continued)

Test Point	Conditions	Comments	Nominal Measurement
A2TP3 (Output Amplifier Output)	Note (2) MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 10 v/cm	
	Note (2) WAVEFORM ⊓⊔	H = 0.2 ms/cm V = 10 v/cm	
	Note (2) WAVEFORM ⊓⊔ MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 10 v/cm	
A2TP5 (Comparator Output)	Note (2) WAVEFORM ⊓⊔ VAR PULSE at Center	H = 0.2 ms/cm V = 2 v/cm	
A2TP6 (Variable Pulse Output)	Note (2) WAVEFORM ⊓⊔ VAR PULSE at Center	H = 0.2 ms/cm V = 5 v/cm	
A2TP7 (Triangle Input)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	
A2TP8 (Sine Shaper Input)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	
A2TP9 (Sine Shaper)	Note (1)	H = 0.2 ms/cm V = 1 v/cm	

(1) See conditions specified in paragraph 5-5g.
(2) Conditions specified in paragraph 5-5g, except as noted.

Table 5-8. Test Point Measurements (Continued)

Test Point	Conditions	Comments	Nominal Measurement
A2TP10 (Sine Shaper)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	
A2TP11 (Sine Shaper Output)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	
	Note (2) MULTIPLIER 100K (1 MHz)	H = 0.2 μs/cm V = 2 v/cm	
A2TP12 (Ground)	None	None	0 volts
A2TP13 (Ground)	None	None	0 volts
A3TP1 (+24-Volt Supply)	None	Read dc	+24 volts
A3TP2 (+5-Volt Supply)	None	Read dc	+5 volts
A3TP3 (-5-Volt Supply)	None	read dc	-5 volts
A3TP4 (-24-Volt Supply)	None	Read dc	-24 volts

(1) See conditions specified in paragraph 5-5g.
(2) Conditions specified in paragraph 5-5g, except as noted.

Table 5-8. Test Point Measurements (Continued)

Test Point	Conditions	Comments	Nominal Measurement
A3TP5 (+12-Volt Supply)	None	Read dc	+12 volts
A3TP6 (Ground)	None	None	0 volts
A3TP7 (-12-Volt Supply)	None	Read dc	-12 volts

NOTES

Section VI
REPLACEABLE PARTS

6-1. INTRODUCTION

This section contains information for identifying and ordering replacement parts. Replacement parts may be ordered from Interstate Electronics Corporation. Be certain that the order or inquiry identifies the part by description and part number.

Table 6-1 is a listing of all manufacturers supplying parts used in the function generator. Manufacturers are listed in numerical order by their respective code symbols.

6-2. PARTS LIST TABLES

Tables 6-2 through 6-4 list all electrical and electronic parts in alphanumeric order by reference designators and provide the following information for each part, where applicable: (a) value, (b) description, (c) total quantity used in the instrument (listed the first time the part number appears), (d) IEC part number, (e) manufacturer's code symbol, and (f) original manufacturer's part number. Mechanical parts are listed at the end of each table.

TABLE 6-1. LIST OF MANUFACTURERS

Code	Manufacturer
00853	Sangamo Electric Co., S. Carolina Division, Pickens, South Carolina
01121	Allen-Bradley Co., Milwaukee, Wisconsin
01295	Texas Instruments Inc., Semiconductor-Components Division, Dallas, Texas
02114	Ferroxcube Corp., of America, Saugerties, New York
02735	RCA Solid State and Receiving Tube Division, Somerville, New Jersey
03508	GE Co., Semi-Conductor Products Dept., Syracuse, New York
03877	Transitron Electronic Corporation, Wakefield, Massachusetts
03879	Akron Controller and Motor Inc., Akron, Ohio
04552	Emerson and Cuming Inc., Canton, Massachusetts
04713	Motorola Semiconductor Products Inc., Phoenix, Arizona
05820	Wakefield Engineering Inc., Wakefield, Massachusetts
07263	Fairchild Camera and Inst. Corp., Mountain View, California
07421	Interstate Electronics Corp., Anaheim, California
07933	Raytheon Co., Lexington, Massachusetts
28480	Hewlett-Packard Co., Palo Alto, California

Table 6-1. List of Manufacturers (Continued)

Code	Manufacturer
49956	Raytheon Co., Lexington, Massachusetts
56289	Sprague Electric Co., North Adams, Massachusetts
71450	CTS Corp., Elkhart, Indiana
71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Illinois
72136	Electric Motive Mfg. Co. Inc., Willimantic, Connecticut
74970	E. F. Johnson Co., Waseca, Minnesota
75042	I R C Inc., Philadelphia, Pennsylvania
75915	Littelfuse Inc., Des Plaines, Illinois
76493	J. W. Miller Co., Los Angeles, California
80294	Bourns Inc., Riverside, California
82389	Switchcraft, Inc., Chicago, Illinois
83330	Herman H. Smith Inc., Brooklyn, New York
84171	ARCO Electronics Inc., Great Neck, New York
84411	TRW Capacitor Division, Ogallala, Nebraska
90201	Mallory Capacitor Co., Indianapolis, Indiana
93332	Sylvania Electric Products Inc., Semiconductor Division, Woburn, Massachusetts
95146	ALCO Electronic Mfg. Co., Lawrence, Massachusetts
97979	Reon Resistor Corp., Yonkers, New York
98978	International Electronic Research Corp., Burbank, California

TABLE 6-2. MAIN BOARD (A1) PARTS LIST

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
R1	2.5K	R: Variable 1 Watt ±20% (See S2)			
R2	250Ω	R: Variable 1/4 Watt ±20%		97979	CLP-250-M
R3	10Ω	R: Metal Glaze 1/2 Watt ±5%		75042	RG20-100-J
R4	1K	R: Variable plastic 1 Watt 20%		80294	3438S-491-102
R5	2.5K	R: Variable 1/4 Watt ±20%		97979	CLP-2.5K-M
R6	1K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1001-F
R7	2.5K	R: Variable 1/4 Watt ±20%		97979	CLP-2.5K-M
R8-R11	1M	R: Metal Film 1/2 Watt ±0.25% ±100 ppm		75042	CCA-T0-1004-C
R12	332K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-3323-C
R13	115K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-1153-C
R14	33.2K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-3322-C
R15	6.65K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-6651-C
R16	1.33K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-1331-C
R17-R20	1M	R: Metal Film 1/2 Watt ±0.25% ±100 ppm		75042	CCA-T0-1004-C
R21	332K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-3323-C
R22	115K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-1153-C
R23	33.2K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-3322-C
R24	6.65K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-6651-C
R25	500Ω	R: Variable 1/4 Watt ±20%		71450	TSV-500
R26	115K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-1153-C
R27	76.8K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-7682-C
R28	Unassigned				
R29	665K	R: Metal Film 1/2 Watt ±0.25% ±100 ppm		75042	CCA-T0-6653-C
R30	210K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-2103-C
R31	23.2K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-2322-C
R32	4.64K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-4641-C
R33	931Ω	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-9310-C
R34	1M	R: Metal Film 1/2 Watt ±0.25% ±100 ppm		75042	CCA-T0-1004-C
R35	121K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-1213-C
R36	1M	R: Metal Film 1/2 Watt ±0.25% ±100 ppm		75042	CEA-T0-1004-C
R37	432K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-4323-C
R38	143K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-1433-C
R39	14.3K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-1432-C
R40	2.87K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-2871-C
R41	576Ω	R: Metal Film 1/2 Watt ±0.25% ±100 ppm		75042	CCA-T0-5760-C
R42	20K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-203-J
R43	2.4M	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-245-J
R44	10K	R: Variable 1/4 Watt ±20%		97979	CLP-10K-M
R45-R46	47K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-473-J
R47	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-152-J
R48	470Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-471-J
R49	130Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-131-J
R51	10K	R: Variable 1/4 Watt ±20%		97979	CLP-10K-M
R52	2.4M	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-245-J

Table 6-2. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
R53	20K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-203-J
R54-R55	62K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-623-J
R57	470Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-471-J
R59	1K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-102-J
R60	51Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-510-J
R61	30K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-303-J
R62	432Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-4320-F
R63	3.32K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-3321-F
R64	30K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-303-J
R65	1K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-102-J
R66	1.47K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1471-F
R67	110Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-111-J
R68-R69	5.6Ω	R: Carbon 1/4 Watt ±5%		75042	RC07GF5R6J
R70	22Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-220-J
R71	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-101-J
R72	51Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-510-J
R73-R74	100Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-101-J
R75	1.96K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1961-F
R76	2.21K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2211-F
R77	432Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-4320-F
R78	1K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-102-J
R79	39K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-393-J
R80	10K	R: Variable 1/4 Watt ±20%		97979	CLP-10K-M
R81	10Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-100-J
R82	22Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-220-J
R83	82Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-820-J
R84	340Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-3400-F
R85	150Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1500-F
R86	75Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-75R0-F
R87	20K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-203-J
R88	Unassigned				
R89	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R90	20K	R: Metal Glaze 1/2 Watt ±5%		75042	RG20-203-J
R91	100K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-104-J
R92	Unassigned				
R93	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R94	20K	R: Metal Glaze 1/2 Watt ±5%		75042	RG20-203-J
R95-R96	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R97	1.8K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-182-J
R98	1.2K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-122-J
R99	825Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-8250-F
R100	2.2K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-222-J
R101	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R102	825Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-8250-F

Table 6-2. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
R103	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R104	1.8K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-182-J
R105	3.3K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-332-J
R106	1.5K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1501-F
R107	715Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-7150-F
R108	1.6K	R: Metal Glaze 1 Watt ±5%		75042	RG32-162-J
R109	560Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-561-J
R110	1.1K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-112-J
R111	100K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-104-J
R112	510Ω	R: Metal Glaze 1 Watt ±5%		75042	RG32-511-J
R113	1.1K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-112-J
R114	56	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-560-J
R115	6.8K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-682-J
R116	56Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-560-J
R117-R118	43	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-430-J
R119	2.2K	R: Metal Glaze 1 Watt ±5%		75042	RG32-222-J
R120	56Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-560-J
R121	75Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-75R0-F
R122	20K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-203-J
R123	357Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-3570-F
R124	340Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-3400-F
R125	866Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-8660-F
R127	1.1K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1101-F
R128	100Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-101-J
R129	100K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-104-J
R130	56	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-560-J
R132	100Ω	R: Variable 1/4 Watt ±20%		97979	CLP-100-M
R133	5K	R: Variable 1/4 Watt ±20%		97979	CLP-5K-M
R134	Unassigned				
R135	390Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-391-J
R136-R137	75	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-750-J
R138	10Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-100-J
R139	1.47K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1471-F
R140-R141	130Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-131-J
R142-R143	5.6K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-562-J
R144	11.6K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1102-F
R145	10.0K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1002-F
R147	20K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2002-F
R148	12.4K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1242-F
R149	4.7K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-472-J
R150	330K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-334-J
R151	50K	R: Variable 1/4 Watt ±20%		97979	CLP-50K-M
R152	120Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-121-J

Table 6-2. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
R153	6.8K	R: Metal Glaze 1/2 Watt ±5%		75042	RG-20-682-J
R154	6.8K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-682-J
R155	7.5K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-752-J
R156	1K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1001-F
R157	2.05K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2051-F
R158-R159	12.1K	R: Metal Film 1/4 Watt ±0.1% ±100 ppm		75042	CEA-T0-1212-B
R160	330K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-334-J
R161	12.1K	R: Metal Film 1/4 Watt ±0.1% ±100 ppm		75042	CEA-T0-1212-B
R162	50K	R: Variable 1/4 Watt ±20%		97979	CLP-50K-M
R163	7.5K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-752-J
R164	12.1K	R: Metal Film 1/4 Watt ±0.1% ±100 ppm		75042	CEA-T0-1212-B
R165	120Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-121-J
R166	6.8K	R: Metal Glaze 1/2 Watt ±5%		75042	RG-20-682-J
R167	6.8K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-682-J
R168	1K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1001-F
R169	2.05K	R: Metal Film 1/4 Watt ±1% ±100 ppm		07421	CEA-T0-2051-F
R170	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R171	4.32K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-4321-F
R172	500Ω	R: Variable 1/4 Watt ±20%		97979	CLP-500-M
R173	1.3K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1301-F
R174	78.7K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-7872-F
R175	11K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1102-F
R176	Unassigned				
R177	1.5K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-152-J
R178	470Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-471-J
R179	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R180	4.32K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-4321-F
R181	500Ω	R: Variable 1/4 Watt ±20%		97979	CLP-500-M
R182	1.3K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1301-F
R183	78.7K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-7872-F
R184	11K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1102-F
R185	Unassigned				
R186	1.5K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-152-J
R187	470Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-471-J
R188	1.18K	R: Metal Film 1/4 Watt ±1%		75042	CEA-T0-1181-F
R189-R190	2.21K	R: Metal Film 1/4 Watt ±1%		75042	CEA-T0-2211-F
R191	1.05K	R: Metal Film 1/4 Watt ±1%		75042	CEA-T0-1051-F
R192	38.3Ω	R: Metal Glaze 1/4 Watt ±5%		75042	CEA-T0-38R3-F
R193	Unassigned				
R194	182Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1540-F
R195-R196	220Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-221-J
R197	91Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-680-J
R198	75Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-75R0-F
R199	150Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1500-F
R200	390Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-391-J
R201	2.5K	R: Variable 1/4 Watt ±20%		97979	CLP-2.5K-M

Table 6-2. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
R202	50Ω	R: Variable 1/4 Watt ±20%		97979	CLP-50-M
R203	432Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-4320-F
R204	4.32K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-4321-F
R205	1K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1001-F
R206	11.0K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1102-F
R207	Unassigned				
R208	(Select)	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-(Select)
R209	38.3	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-38R3-F
R210	909Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-9090-F
C1	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C2	15μf	C: Electrolytic 50 volts +75% -10%		56289	30D156G050CB2
C3	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C4	15μf	C: Electrolytic 50 volts +75% -10%		56289	30D156G050CB2
C5	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C6	15μf	C: Electrolytic 50 volts +75% -10%		56289	30D156G050CB2
C7	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C8	15μf	C: Electrolytic 50 volts +75% -10%		56289	30D156G050CB2
C9	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C10	20μf	C: Electrolytic 15 volts +75% -10%		56289	30D206G016BB2
C11	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C12	20μf	C: Electrolytic 15 volts +75% -10%		56289	30D206G016BB2
C13	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C18	Unassigned				
C19	10pf	C: Mica 500 volts ±10%		72136	CM05-ED-100K
C21	Unassigned				
C22	10μf	C: Metalized Mylar 100 volts ±5%		84411	X663FR10651W2
C23	0.1μf	C: Polyester 50 volts ±2%		56289	414P-1042R5
C24	750pf	C: Mica 300 volts ±2%		00853	CM05-ED-751G
C25	220pf	C: Mica 500 volts ±2%		00853	CM05-ED-221G
C26	0.01μf	C: Ceramic 100 volts ±20%		56289	C023A101F103M
C27	2.4-24.5pf	C: Variable Air Dielectric		74970	189-509-5
C28	Unassigned				
C29	0.01μf	C: Ceramic 100 volts ±20%		56289	C023A101F103M
C30	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C31	2.4-24.5pf	C: Variable Air Dielectric		74970	189-509-5
C32-C33	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C34	3pf	C: Mica 500 volts ±0.5pf		72136	DM15-050K
C35-C36	Unassigned				
C37-C38	0.33pf	C: Ceramic 100 volts ±20%		56289	C080A120M334Y
C39	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C40-C41	Unassigned				
C42	20μf	C: Electrolytic 15 volts +75% -10%		56289	30D206G016BB2
C43-C50	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C51-C52	(Select)	C: Mica 500 volts ±10%		00853	
C55	180pf	C: Mica 500 volts ±2%		00853	CM05-ED-181G
C56-C57	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C

Table 6-2. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
C65	0.1µf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C66	200pf	C: Mica 500 volts ±10%		00853	CM05-ED-201K
C67	0.0047pf	C: Ceramic 25 volts ±20%		56289	C069A250C472M
C68	0.1µf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C69	200pf	C: Mica 500 volts ±10%		00853	CM05-ED-201K
C70	0.0047pf	C: Ceramic 25 volts ±20%		56289	C069A250C472M
C71-C73	Unassigned				
C74-C78	0.1µf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C79	(Select)	C: Mica 500 volts ±10%		72136	CM05-(Select)
C80	0.01µf	C: Ceramic 100 volts ±20%		56289	C023A101F103M
C81	0.001µf	C: Ceramic 1000 volts ±20%		56289	C016A102G102M
C84	5pf	C: Mica 500 volts ±10%		72136	CM05-ED-050K
Q1-Q2		TSTR: Dual N-Channel FET	P00347201	07421	2N 3958
Q3		TSTR: P-Channel FET	P00347250	07421	UC 400
Q4		TSTR: N-Channel FET	P00347202	07421	2N 4092
Q5		TSTR: Silicon PNP	P00347100	07421	
Q6		TSTR: Silicon NPN	P00347000	07421	
Q7		TSTR: Dual N-Channel FET	P00347201	07421	
Q8		TSTR: Silicon PNP	P00347101	07421	
Q9		TSTR: Silicon NPN		02735	2N 5187
Q10		TSTR: Silicon PNP		07263	2N 4258
Q11		TSTR: Silicon PNP	P00347101	07421	
Q12		TSTR: Silicon NPN		02735	2N 5187
Q13		TSTR: Silicon NPN		04713	2N 3904
Q14		TSTR: Silicon PNP		04713	2N 3906
Q15-Q16		TSTR: Silicon NPN		04713	2N 3904
Q17		TSTR: Silicon PNP	P00347103	07421	
Q18		TSTR: Silicon NPN	P00347003	07421	
Q19		TSTR: Silicon PNP	P00347103	07421	
Q20		TSTR: Silicon NPN	P00347003	07421	
Q21		TSTR: Silicon PNP	P00347103	07421	
Q22		TSTR: Silicon NPN		04713	2N 3904
Q23		TSTR: Silicon PNP		04713	2N 3906
Q24		TSTR: Silicon PNP	P00347103	07421	
Q25		TSTR: Silicon PNP		07263	2N 4258
Q26-Q27		TSTR: Silicon PNP		04713	2N 3906
Q28-Q29		TSTR: Silicon NPN		04713	2N 3904
Q30		TSTR: Silicon PNP		07263	2N 4258
Q31		TSTR: Silicon NPN		02735	2N 5187
Q32		TSTR: Silicon NPN		04713	2N 3904
Q33		TSTR: Silicon PNP		04713	2N 3906
Q34		TSTR: Silicon PNP	P00347101	07421	

Table 6-2. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
IC1-IC2		Integrated Circuit Amp 741		01295	72741N
IC3		Integrated Circuit Array		02735	CA 3049
IC4-IC5		Integrated Circuit Array		02735	CA 3018A
IC6-IC7		Integrated Circuit Amp 741		01295	72741N
IC8-IC9		Integrated Circuit Amp 709		03877	T0A2709E
CR1		Diode: Switching Hot Carrier		28480	HP-5082-2811
CR2-CR3		Diode: Low Leakage		07263	FD333
CR4		Diode: Switching Hot Carrier		28480	HP-5082-2811
CR5		Diode: Low Leakage		07263	FD333
CR6-CR7		Diode: Switching Hot Carrier		28480	HP-5082-2811
CR8		Diode: Low Leakage		07263	FD333
CR9	6.2v	Diode: Zener 400 mw ±5%		04713	1N 5234B
CR10-CR11		Diode: Silicon		03508	1N 914A
CR12-CR13		Diode: Switching Hot Carrier, Matched		28480	HP-5082-2816
CR14-CR16		Diode: Silicon		03508	1N 914A
CR17	5.6v	Diode: Zener 400 mw ±5%		07413	1N 5232B
CR18-CR19		Diode: Silicon		03508	1N 914A
CR20		Diode: Switching Hot Carrier		28480	HP-5082-2811
CR21		Diode: Silicon		03508	1N 914A
CR22		Diode: Tunnel		03508	1N 3719
CR23	4.7v	Diode: Zener 400 mw ±5%		04713	1N 5230B
CR24		Diode: Silicon		03508	1N 914A
CR25		Diode: Tunnel		03508	1N 3719
CR26-CR27		Diode: Silicon		03508	1N 914A
CR28	3v	Diode: Zener 400 mw ±5%		04713	1N 5225B
CR29	Unassigned				
CR30-CR33		Diode: Silicon		03508	1N 914A
CR34	4.7v	Diode: Zener 400 mw ±5%		04713	1N 5230B
CR35	3.9v	Diode: Zener 400 mw ±5%		04713	1N 5228B
CR36		Diode: Silicon		03508	1N 914A
CR37	Unassigned				
CR38		Diode: Switching Hot Carrier		28480	HP-5082-2811
CR39	4.7v	Diode: Zener 400 mw ±5%		04713	1N 5230B
CR40-CR42		Diode: Silicon		03508	1N 914A
S1		Switch: Rotary, 8 poles, 10 positions	PR0333022E	07421	
S2/R1		Switch: Rotary, 4 poles, 8 positions With Potentiometer R1	PR0333021G	07421	
TP1-TP22, E20-E25		Test Point Pins		00779	61067-1

Table 6-2. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
		-- Mechanical Parts --			
		Knobs - Var. Pulse and Waveform	P00333024-2J	07421	
		Knob - Multiplier	P00333024-6J	07421	
		Freq. Knob Assy.	P00333100-6	07421	
		Heat Dissipator for IC3		98978	TXBF-032-025B
		Shielding Bead			2643002301
		Knob, Freq Vernier	PR0333024-9J	07421	

TABLE 6-3. AUXILIARY BOARD (A2) PARTS LIST

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
R1	2.5K	R: Variable 1 Watt ±20%	P00333023	07421	
R2	1.62K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1621-F
R3	250Ω	R: Variable 1/4 Watt ±20%		97979	CLP-250-M
R4-R5	309Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-3090-F
R6	250Ω	R: Variable 1/4 Watt ±20%		97979	CLP-250-M
R7	1.62K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1621-F
R8	500Ω	R: Variable 2 Watt ±10%	P00333025	07421	
R9	10Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-100-J
R10	1000Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1001-F
R11	150Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-151-J
R12	2K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-202-J
R13	2.05K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEB-T0-2051-F
R14	240Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-241-J
R15-R16	61.9Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-61R9-F
R17	2.05K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2051-F
R18	224Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2240-F
R19	4.7K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-472-J
R20	200Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-201-J
R21	5.62K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-5621-F
R22	215Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2150-F
R23	5.62K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-5621-F
R24	200Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-201-J
R25	2430Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2431-F
R26	619Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-6190-F
R27-R28	100Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-101-J
R29	470Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-471-J
R30	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R31	3010Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-3011-F
R32	2K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2001-F
R33	330Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-331-J
R34	1.8K	R: Metal Glaze 1/2 Watt ±5%		75042	RG20-182-J
R35	2430Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2431-F
R36	3010Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-3011-F
R37	110Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-111-J
R38	91Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-910-J
R39	51Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-510-J
R40	110Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-111-J
R41	102Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1020-F
R42	619Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-6190-F
R43-R44	909Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-9090-F
R45	619Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-6190-F
R46-R47	110Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-111-J
R48	30.9Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-30R9-F
R49	22Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-220-J
R51	30.9Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-30R9-F

Table 6-3. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
R52-R53	39Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-390-J
R54	50K	R: Variable 1/4 Watt ±20%		97979	CLP-50K-M
R55	7.5K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-752-J
R56	825Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-8250-F
R57	22Ω	R: Metal Glaze 1 Watt ±5%		75042	RG32-220-J
R58-R59	10Ω	R: Carbon 1/4 Watt ±5%		75042	RC07GF-100-J
R60	22Ω	R: Metal Glaze 1 Watt ±5%		75042	RG32-220-J
R61	47Ω	R: Metal Glaze 2 Watt ±5%		75042	RG2-470-J
R62	1500Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1501-F
R63	51.1Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-51R1-F
R64-R122	Unassigned				
R123	4.7Ω	R: Carbon 1/4 Watt ±5%		75042	RC07GF-4R7-J
R124	22Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-220-J
R125	470Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-471-J
R126	Unassigned				
R127	4.7Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RC07GF-4R7-J
R128	470Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-471-J
R129	30Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-300-J
R130	182Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1820-F
R131-R132	10Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-100-J
R133	1.2K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-122-J
R134	500Ω	R: Variable 1/4 Watt ±20%		97979	CLP-500-M
R135	620Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-621-J
R136	43Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-430-J
R137	430Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-431-J
R138	4.7K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-472-J
R139	7.5Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-7R5-J
R140	22.1Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-22R1-F
R141	39.2Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-39R2-F
R142	47.5Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-47R5-F
R143	130Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1300-F
R144	182Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1820-F
R145	1.2K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-122-J
R146	500Ω	R: Variable 1/4 Watt ±20%		97979	CLP-500-M
R147	620Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-621-J
R148	430Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-431-J
R149	340Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-3400-F
R150-R151	15Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-150-J
R152	1.6K	R: Metal Glaze 1 Watt ±5%		75042	RG32-162-J
R153	1K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-102-J
R154	30.9Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-3090-F
R155	137Ω	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1370-F
R156	1.47K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1471-F
R157	2.5K	R: Variable 1/4 Watt ±20%		97979	CLP-2.5K-M
R158	51Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-510-J
R159-R160	10Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-100-J
R161	22	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-220-J

Table 6-3. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
R162	250Ω	R: Variable 1/4 Watt ±20%		97979	CLP-250-M
R163	51Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-510-J
R164	240Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-241-J
R165 & R167	Unassigned				
R166	30Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-300-J
R168	100Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-101-J
R169	2.49K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2491-F
R170	4.7K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-472-J
R171	1K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-1001-F
R172/R173	30Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-300-J
R174	50Ω	R: Variable 1/4 Watt ±20%		97979	CLP-50-M
R175	2.05K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2051-F
C1-C2	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C3-C6	0.002μf	C: Ceramic 1000 volts ±20%		56289	C016A102J202M
C7-C9	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C10	20pf	C: Ceramic 1000 volts ±10%		56289	C030A102E200K
C11-C12	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C13	Unassigned				
C14-C17	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C18	1.8-16.7pf	C: Variable Air Trimmer		74970	189-506-5
C19	0.001μf	C: Ceramic 1000 volts ±20%		56289	C016A102G102M
C20-C22	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C23-C24	15μf	C: Electrolytic 50 volts +75% -10%		56289	30D156G050CB2
C25	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C26	Unassigned				
C27-C28	27pf	C: Ceramic 500 volts ±5%		00853	CM05-ED-270J
C29-C33	Unassigned				
C34	15μf	C: Electrolytic 50 volts +75% -10%		56289	30D156G050CB2
C35	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C36	15μf	C: Electrolytic 50 volts +75% -10%		56289	30D156G050CB2
C37	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C38	15μf	C: Electrolytic 50 volts +75% -10%		56289	30D156G050CB2
C39	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C40	15μf	C: Electrolytic 50 volts +75% -10%		56289	30D156G050CB2
C41	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C42	20μf	C: Electrolytic 15 volts +75% -10%		56289	30D206C16BB2
C43	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C44	20μf	C: Electrolytic 15 volts +75% -10%		56289	30D206C16BB2
C45-C46	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C47	100pf	C: Ceramic 1000 volts ±10%		56289	C030A102L101K
C48	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C49	100pf	C: Ceramic 1000 volts ±10%		56289	C030A102L101K
C50-C51	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C52	5pf	C: Mica 500 volts ±0.5pf		00853	CM05-ED-050K
C53	0.01μf	C: Ceramic 100 volts ±20%		56289	C023A101F103M
C54-C57	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C

Table 6-3. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
C58	2.4-24.5pf	C: Variable Air Trimmer		74970	189-509-5
C59	0.01μf	C: Ceramic 100 volts ±20%		56289	C023A101F103M
C60	150pf	C: Mica 500 volts ±10%		00853	CM05-ED-151K
C65	36pf	C: Mica 500 volts ±10%		00853	CM05-ED-360K
C66	200pf	C: Mica 500 volts ±10%		00853	CM05-ED-201K
Q1		TSTR: Silicon NPN		04713	2N 3904
Q2-Q3		TSTR: Silicon NPN		02735	2N 3261
Q4		TSTR: Silicon NPN		04713	2N 3904
Q5	Unassigned				
Q6-Q7		TSTR: Silicon NPN		02735	2N 5187
Q8		TSTR: Silicon NPN		04713	2N 3904
Q9		TSTR: Silicon PNP		04713	2N 3906
Q10		TSTR: Silicon PNP		07263	2N 4258
Q11		TSTR: Silicon PNP	P00347104	07421	
Q12		TSTR: Silicon NPN	P00347003	07421	
Q13		TSTR: Silicon NPN		02735	2N 3261
Q14		TSTR: Silicon PNP	P00347009	07421	
Q15		TSTR: Silicon PNP	P00347105	02735	2N 5189
Q16		TSTR: Silicon NPN		07421	MM 4018
Q17		TSTR: Silicon PNP		04713	2N 2905A
Q18-Q33	Unassigned				
Q34		TSTR: Silicon PNP		04713	2N 3906
Q35-Q36		TSTR: Silicon NPN		04713	2N 3904
Q37		TSTR: Silicon PNP		04713	2N 3906
Q38-Q39		TSTR: Silicon NPN		04713	2N 3904
Q40-Q46		TSTR: Silicon PNP		04713	2N 4258
Q47-Q53		TSTR: Silicon NPN		04713	2N 5187
Q54-Q55		TSTR: Silicon PNP		04713	2N 3906
Q56-Q57		TSTR: Silicon NPN		02735	RCA40235
Q58		TSTR: Silicon PNP	P00347101	02735	
Q59		TSTR: Silicon NPN		04713	2N 5187
Q60		TSTR: Silicon PNP		07263	2N 4258
IC1		Integrated Circuit Comparator 710		03877	TDC 2710E
CR1-CR2		Diode: Silicon		03508	1N 914A
CR3	Unassigned				
CR4	12v	Diode: Zener		04713	1N 5242B
CR5-CR8		Diode: Silicon		03508	1N 914A
CR9-CR10		Diode: Silicon		03508	1N 4153
CR11-CR15	Unassigned				
CR16-CR17		Diode: Silicon		03508	1N 914A
CR18-CR19	Unassigned				
CR20-CR21		Diode: Silicon		03508	1N 914A
L1	3.9μh	Inductor: Fixed ±10%		76493	9310-26
S1		Switch: Rotary 2 poles, 4 positions	P00333023	07421	
S2		Switch: SPST (part of R8)	P00333025	01121	
		Connector Assy, 19 pin		00779	1-85928-1
RN1-RN2		Resistor Network	P00334023		

Table 6-3. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
		-- Mechanical Parts List --			
		Heat Dissipator: Q2, 3, 11, 12		98978	TXBF-019-025B
		Heat Dissipator: Q16, 17		98978	TXB2-032-037B
		Knob, Offset-Adj	PR0333024-1J	07421	
		Knob, Output Level, On-Off	PR0333024-10J	07421	
		Shielding Bead		02114	2643002301
		Bulkhead Receiptacle, BNC, Round Mtg. Flange	Y70B3000	02660	UG-625B/U

TABLE 6-4. POWER SUPPLY BOARD (A3) PARTS LIST

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
R1	130Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-131-J
R2	24K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-243-J
R3	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R4	2.4Ω	R: Carbon 1 Watt ±5%		75042	RC32GF-2R4-J
R7	2.7K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-272-J
R8-R9	10K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-1002-C
R10	10K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-103-J
R12	2.4Ω	R: Carbon 1 Watt ±5%		75042	RC32GF-2R4-J
R14	2.7K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-272-J
R15	12.4K	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-1242-C
R16	6190Ω	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-6191-C
R17	24K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-243-J
R18	130Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-131-J
R19	2.7Ω	R: Carbon 1 Watt ±5%		75042	RC32GF-2R7-J
R20	11K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-113-J
R21	3.6K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-362-J
R22-R23	470Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-471-J
R24-R25	4.7Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-4R7-J
R26	3K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-302-J
R27	2.7K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-272-J
R28	2K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2001-F
R29	1K	R: Variable 1 Watt ±20%		97979	CLP-1K-M
R30	2.67K	R: Metal Film 1/4 Watt ±1% ±100 ppm		75042	CEA-T0-2671-F
R31	3.6K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-362-J
R32	11K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-113-J
R33	470Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-471-J
R34	2.7Ω	R: Carbon 1 Watt ±5%		75042	RC326F-2R7-J
R35	2.7K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-272-J
R36	4750Ω	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-4751-C
R37	4.2Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-4R7-J
R41	4750Ω	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-4751-C
R42	680Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-681-J
R43	1K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-102-J
R44	6190Ω	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-6191-C
R45-R46	4990Ω	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-4991-C
R47	6190Ω	R: Metal Film 1/4 Watt ±0.25% ±100 ppm		75042	CEA-T0-6191-C
R48	680Ω	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-681-J
R49	1K	R: Metal Glaze 1/4 Watt ±5%		75042	RG1/4-102-J
R51-R52	5.1K	R: Metal Glaze 1/2 Watt ±5%		75042	RG20-512-J
C1	1250μf	C: Electrolytic 50 volts +150% -10%		90201	20-35890
C4	100μf	C: Electrolytic 50 volts +100% -10%		90201	20-44818
C5	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C6	1250μf	C: Electrolytic 50 volts +150% -10%		90201	20-35890
C9	100μf	C: Electrolytic 50 volts +100% -10%		90201	20-44818
C10	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C14	0.01μf	C: Ceramic 100 volts ±20%		56289	C023A101F103M

Table 6-4. Power Supply Board (A3) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	IEC P/N	MFR	MFR P/N
C15	100μf	C: Electrolytic 50 volts +100% -10%		90201	20-44818
C16	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C17-C18	1500μf	C: Electrolytic 25 volts +150% -10%		90201	20-35889
C22	100μf	C: Electrolytic 50 volts +100% -10%		90201	20-44818
C23	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C24	100μf	C: Electrolytic 15 volts +100% -10%		90201	20-44823
C25	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C26	100μf	C: Electrolytic 15 volts +100% -10%		90201	20-44823
C27	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C28-C29	0.1μf	C: Ceramic 100 volts +80% -20%		56289	33C41C
C33	0.01μf	C: Ceramic 100 volts ±20%		56289	C023A101F103M
Q1		TSTR: Silicon NPN		02195	TIP29A
Q2		TSTR: Silicon NPN		02735	2N 2219A
Q3		TSTR: Silicon NPN		02735	2N 3904
Q4		TSTR: Silicon PNP		02735	2N 3906
Q5		TSTR: Silicon PNP		02735	2N 2905A
Q6		TSTR: Silicon PNP		01295	TIP30A
Q7		TSTR: Silicon NPN		02195	TIP29A
Q8		TSTR: Silicon NPN		56289	2N 2219A
Q9		TSTR: Silicon NPN		56289	2N 3904
Q10		TSTR: Silicon PNP		56289	2N 3906
Q11		TSTR: Silicon PNP		56289	2N 2905A
Q12		TSTR: Silicon PNP		02195	TIP30A
Q13		TSTR: Silicon PNP		02195	TIP30A
Q14		TSTR: Silicon NPN		04713	2N 3904
Q15		TSTR: Silicon PNP		04713	2N 3906
Q16		TSTR: Silicon NPN		02591	TIP29A
IC1-IC4		Integrated Circuit: Amp 741		02195	72741N
CR1-CR4		Diode: Silicon 100 volts PRV 1 Amp		04713	1N 4002
CR5 & CR8	27.0v	Diode: Zener 400 mw ±5%	P00347350-270	04713	1N 3254B
CR11-CR14		Diode: Silicon 100 volts PRV 1 Amp		04713	1N 4002
CR15	10.0v	Diode: Zener 400 mw ±5%	P00347350-100	04713	1N 4250B
CR17 & CR18		Diode: Silicon		03508	1N 914A
CR19	6.2v	Diode: Zener 400 mw ±5%	PO00347350-062	04713	1N 5234B
CR20	15.0v	Diode: Zener 400 mw ±5%	P00347350-150	04713	1N 5245B
CR23-CR26		Diode: Silicon		03508	1N 914A
S1		Switch: Slide DPDT Locking		82389	46256LF
T1		Transformer: Power	PR0333920B	07421	
DS1		Lamp: Power Indicator		95146	MNE-4SLA
F1	0.5 amp/ 0.25 amp	Fuse: 3AG SLO-BLO 1/2 A/115v - 1/4 A/230v		75195	3AG1/2A - 3AG1/4A
		-- Mechanical Parts List --			
		Miniature 3AG Fuse Post		75915	342022
		Bulkhead Receptacle BNC		07421	UG-625B/U

NOTES

Section VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION

This section contains the functional block diagram, detailed schematic diagrams, and component location diagrams and tables for the Model F51A Function Generator.

7-2. FUNCTIONAL BLOCK DIAGRAM

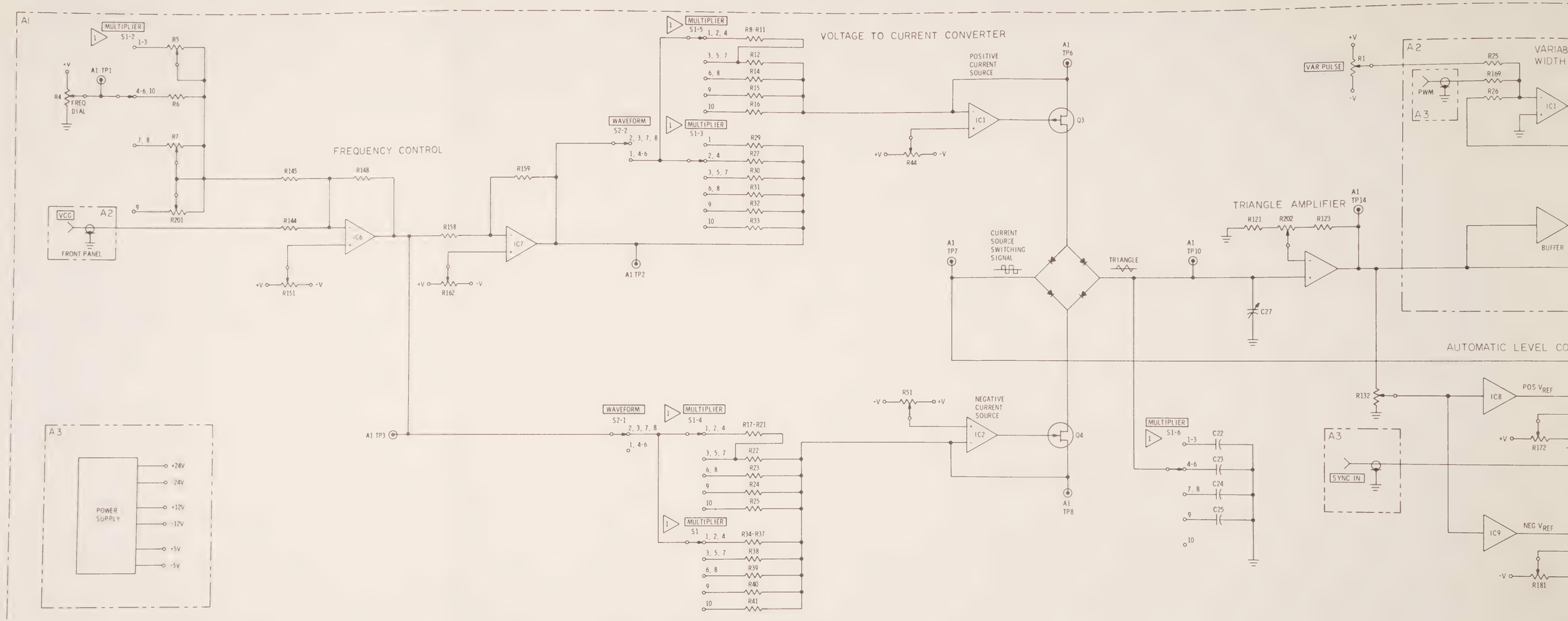
Figure 7-1 is a functional block diagram of the entire function generator showing important test points and the variable components used in the adjustment and calibration procedure.

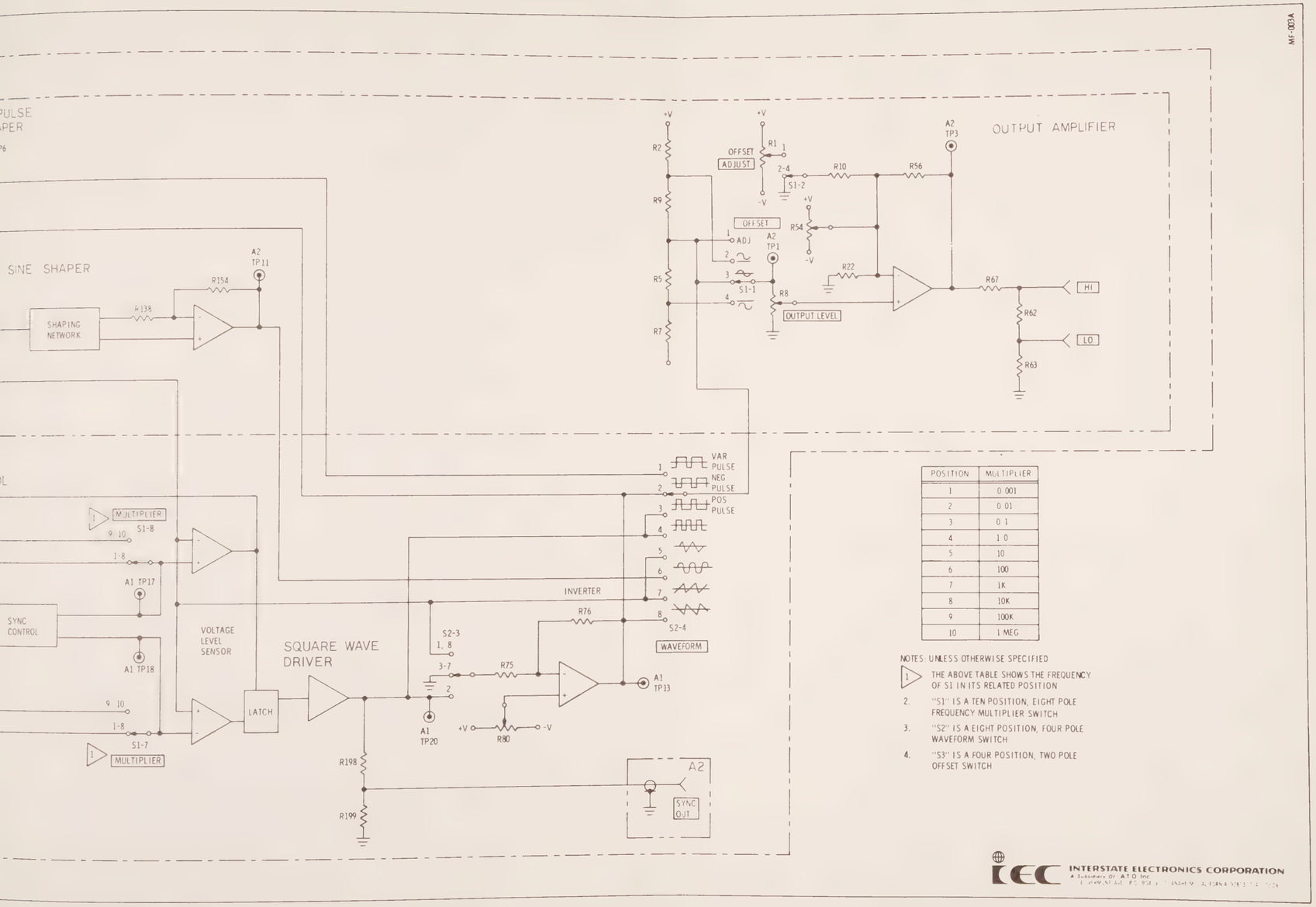
7-3. SCHEMATIC DIAGRAMS

Figures 7-3, 7-5, and 7-7 are detailed schematic diagrams of the circuits in the function generator. Special emphasis has been placed on illustrating all integrated circuit packages in their top view position and actual physical appearance. All wafer-type switches are physically illustrated with their connecting components. An overall unit schematic diagram, showing the major signal path in heavy lines, is also supplied, in separate cover, with this manual. Included on this complete schematic are test point waveforms and measurements, test point locations, and adjustment locations.

7-4. COMPONENT LOCATION DIAGRAMS

Figures 7-2, 7-4, and 7-6 are component location (assembly) diagrams. These assembly diagrams, and tables 7-1 through 7-3, will assist in the identification and location of components and test points on each board.


A1
MULTIPLIER
S1-2
1-3
R5
+V
A1 TP1
R4
FREQ DIAL
4-6, 10
R6
7, 8
R7
9
R201
VCG
A2
FRONT PANEL
FREQUENCY CONTROL
R145
R148
R144
R151
+V
-V
+G6
R158
R159
IC7
R162
WAVEFORM
S2-2
2, 3, 7, 8
1, 4-6
MULTIPLIER
S1-5
1, 2, 4
R8-R11
3, 5, 7
R12
6, 8
R14
9
R15
10
R16
MULTIPLIER
S1-3
1
R29
2, 4
R27
3, 5, 7
R30
6, 8
R31
9
R32
10
R33
A1 TP2
VOLTAGE TO CURRENT CONVERTER
POSITIVE CURRENT SOURCE
IC1
R44
A1 TP6
Q3
A1 TP7
CURRENT SOURCE SWITCHING SIGNAL
TRIANGLE
A1 TP10
TRIANGLE AMPLIFIER
R121
R202
R123
A1 TP14
C27
VAR PULSE
R1
A2
PWM
A3
R25
R169
R26
IC1
BUFFER
AUTOMATIC LEVEL CO
A1 TP3
WAVEFORM
S2-1
2, 3, 7, 8
1, 4-6
MULTIPLIER
S1-4
1, 2, 4
R17-R21
3, 5, 7
R22
6, 8
R23
9
R24
10
R25
MULTIPLIER
S1
1, 2, 4
R34-R37
3, 5, 7
R38
6, 8
R39
9
R40
10
R41
R51
NEGATIVE CURRENT SOURCE
IC2
Q4
A1 TP8
MULTIPLIER
S1-6
1-3
C22
4-6
C23
7, 8
C24
9
C25
10
R132
IC8
POS VREF
R172
A3
SYNC IN
IC9
NEG VREF
R181
A3
POWER SUPPLY
+24V
-24V
+12V
-12V
+5V
-5V



POSITION	MULTIPLIER
1	0.001
2	0.01
3	0.1
4	1.0
5	10
6	100
7	1K
8	10K
9	100K
10	1 MEG

NOTES: UNLESS OTHERWISE SPECIFIED

1. THE ABOVE TABLE SHOWS THE FREQUENCY OF S1 IN ITS RELATED POSITION
2. "S1" IS A TEN POSITION, EIGHT POLE FREQUENCY MULTIPLIER SWITCH
3. "S2" IS A EIGHT POSITION, FOUR POLE WAVEFORM SWITCH
4. "S3" IS A FOUR POSITION, TWO POLE OFFSET SWITCH

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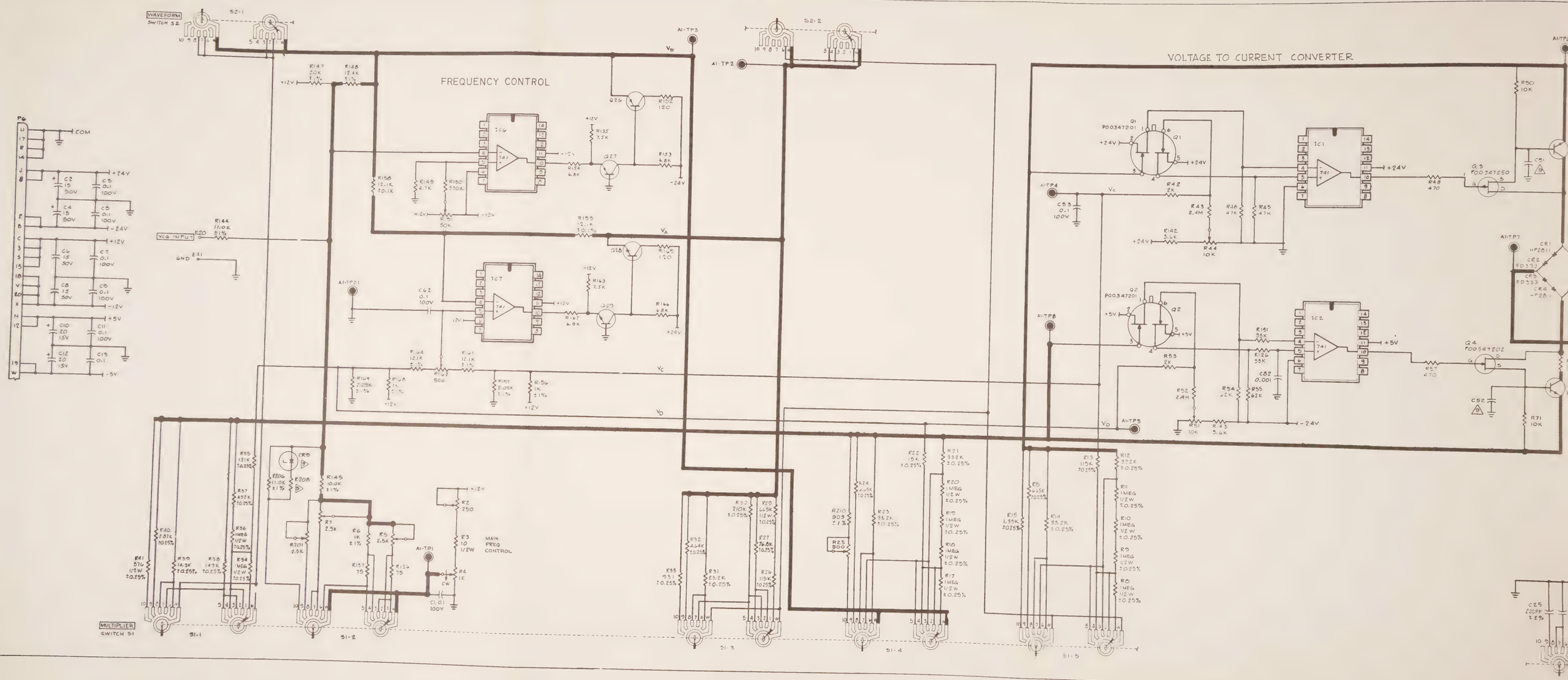
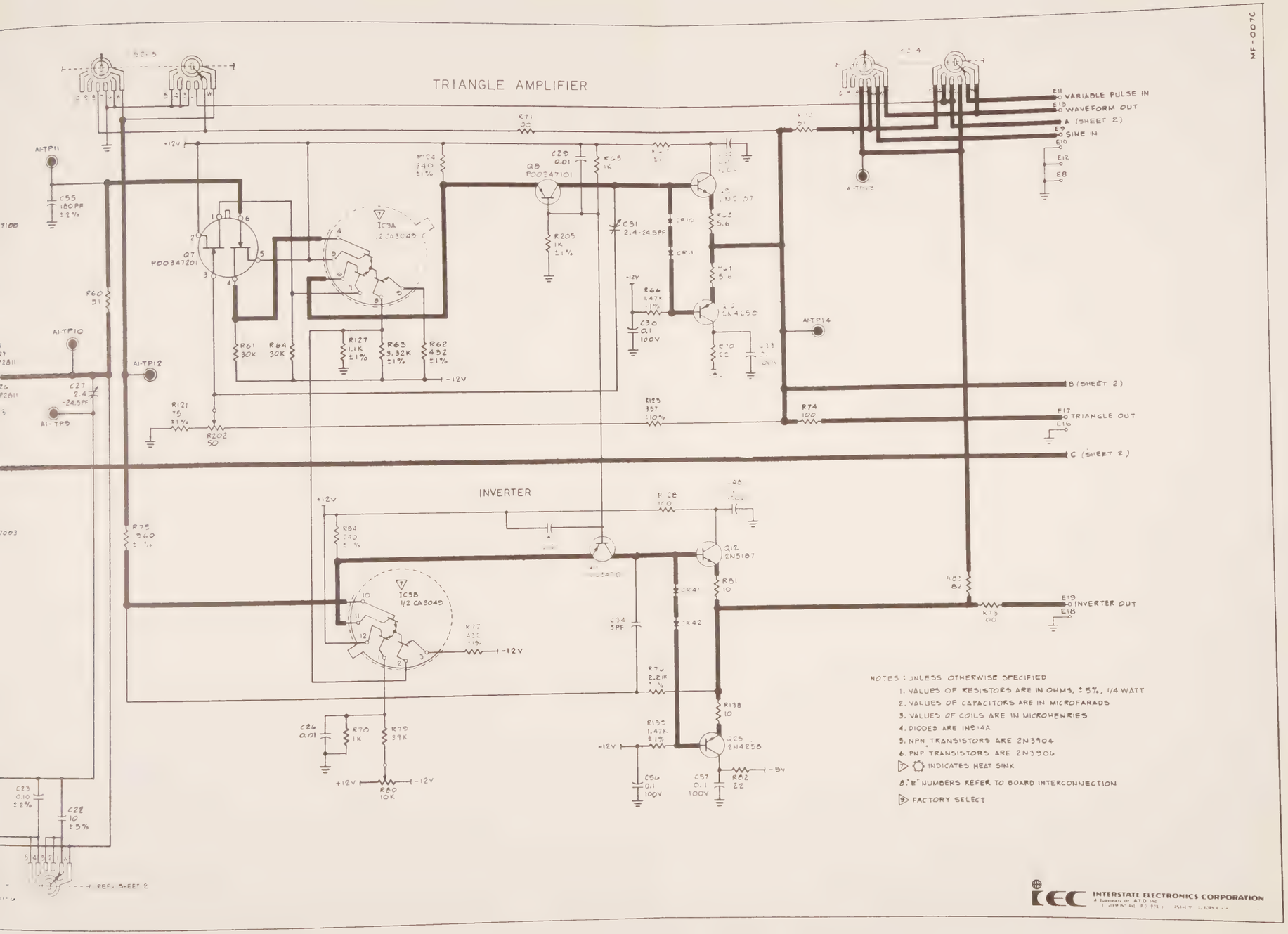
Figure 7-1. Functional Block Diagram


FREQUENCY CONTROL
VOLTAGE TO CURRENT CONVERTER
WAVEFORM SWITCH S2
MULTIPLIER SWITCH S1
VCG INPUT
GND
MAIN FREQ CONTROL
+24V
-24V
+12V
-12V
+5V
COM
P6
S1-1
S1-2
S1-3
S1-4
S1-5
S2-1
S2-2
A1-TP1
A1-TP2
A1-TP3
A1-TP4
A1-TP5
A1-TP7
A1-TP8
A1-TP21
VB
VA
VC
VD
Q1
P00347201
Q2
P00347201
Q3
P00347250
Q4
P00347202
IC1
IC2
IC6
IC7
741
CR1
HP2811
CR2
FD333
CR3
FD333
CR4
HP2811
CR5
CR6
R144
11.0K
R147
20K
R148
12.4K
R158
12.1K
R159
12.1K
R160
330K
R161
50K
R162
12C
R163
7.5K
R164
12.1K
R165
12C
R166
6.8K
R167
6.8K
R168
12.1K
R169
2.05K
R170
1K
R171
560
R172
12.1K
R173
1K
R174
2.05K
R175
1K
R176
1K
R135
7.5K
R153
6.8K
R154
6.8K
R155
121K
R156
14.3K
R157
432K
R158
1MEG
R159
143K
R160
1MEG
R161
576
R162
2.87K
R163
14.3K
R164
1MEG
R165
121K
R166
11.0K
R167
2.5K
R168
10.0K
R169
2.5K
R170
75
R171
75
R172
2.5K
R173
2.5K
R174
1K
R175
1K
R176
250
R177
10
R178
1K
R179
CW
R180
1K
R181
2.5K
R182
2K
R183
2.4M
R184
10K
R185
47K
R186
47K
R187
2K
R188
2.4M
R189
10K
R190
55K
R191
62K
R192
10K
R193
5.6K
R194
2K
R195
55K
R196
62K
R197
470
R198
470
R199
10K
R200
10K
R201
2.5K
R202
11.0K
R203
2.5K
R204
2.5K
R205
2.5K
R206
11.0K
R207
2.5K
R208
11.0K
R209
2.5K
R210
909
R211
909
R212
332K
R213
115K
R214
33.2K
R215
1.35K
R216
4.45K
R217
332K
R218
1MEG
R219
1MEG
R220
1MEG
R221
332K
R222
15K
R223
33.2K
R224
4.45K
R225
500
R226
1MEG
R227
76.8K
R228
115K
R229
4.45K
R230
210K
R231
33.2K
R232
4.64K
R233
931
R234
1MEG
R235
1MEG
R236
1MEG
R237
1MEG
R238
1MEG
R239
1MEG
R240
2.87K
C1
.01
100V
C2
15
50V
C3
0.1
100V
C4
15
50V
C5
0.1
100V
C6
15
50V
C7
0.1
100V
C8
15
50V
C9
0.1
100V
C10
20
15V
C11
0.1
100V
C12
20
15V
C13
0.1
C51
C52
C53
0.1
100V
C62
0.1
100V
C62
0.001
C25
220PF
±2%



NOTES : UNLESS OTHERWISE SPECIFIED

1. VALUES OF RESISTORS ARE IN OHMS, ±5%, 1/4 WATT
2. VALUES OF CAPACITORS ARE IN MICROFARADS
3. VALUES OF COILS ARE IN MICROHENRIES
4. DIODES ARE IN914A
5. NPN TRANSISTORS ARE 2N3904
6. PNP TRANSISTORS ARE 2N3906

▷○ INDICATES HEAT SINK

8."B" NUMBERS REFER TO BOARD INTERCONNECTION

▷ FACTORY SELECT

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Figure 7-3. Main Board (A1) Schematic (Sheet 1 of 2 sheets)

A1

AUTOMATIC LEVEL CONTROL

SYNC CONTROL

VOLTAGE LEVEL SENSOR

SHEET 1

A

B

C

R170 10K

R87 20K

R171 4.32K ±1%

R172 500

R173 4.30K ±1%

C37 0.1 100V

CR12 HP5082-2816

R174 78.7K ±1%

R177 1.5K

IC6 709

C67 0.0047 25V

C65 0.1 100V

C75 0.1 100V

R178 470

C66 200PF

R175 11K ±1%

C74 0.1 100V

-3V

CR30

A1-TP15

R85 75 ±1%

R132 100

CR13 HP5082-2816

R85 50 ±1%

R179 10K

R122 20K

C38 0.1 100V

R180 4.32K ±1%

R181 500

R182 4.30K ±1%

R186 1.5K

IC7 709

C70 0.0047 25V

C68 0.1 100V

R183 78.7K ±1%

R184 1K ±1%

R187 470

CR40

+3V

10 9 8 7 6 W

5 4 3 2 1 W

(REF) H

S1-7 MULTIPLIER

S1-8

R205 492 ±1%

C81 0.001

VR(+)

VR(-)

A1-TP17

A1-TP16

R105 3.3K

R89 10K

R90 20K 1/2W

Q13

CR14

R91 100K

R204 4.32K ±1%

R140 130

C49 0.1 100V

IC4 CA3018A

R97 1.8K

R95 10K

R96 10K

Q15

CR17 5.6V

CR18

C39 0.1 100V

R99 825 ±1%

A1-TP18

R141 130

CR16

+3V

R93 10K

R94 20K 1/2W

Q14

CR15

R100 2.2K

C50 0.1 100V

IC5 CA3018A

R104 1.8K

R101 10K

R103 10K

Q16

R98 1.2K

R102 825 ±1%

Q24 P003471103

CR23 4.7V

R114 56

C7_ 0.1 100V

CR25 IN5715

R125 866 ±1%

R123 100K

CR24

+24V

R130 56

A1-TP19

CR22 IN5719

R106 1.5K ±1%

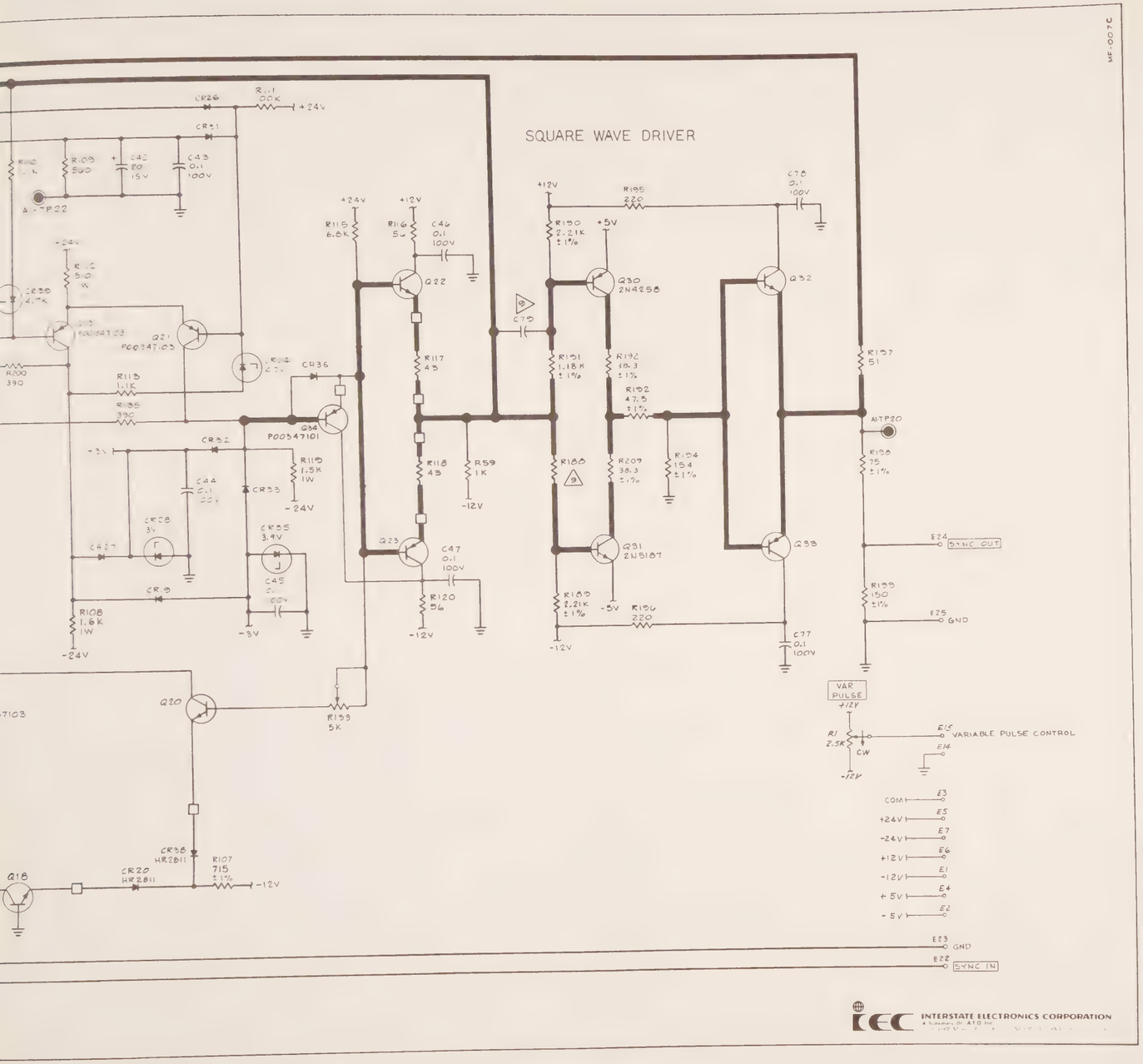
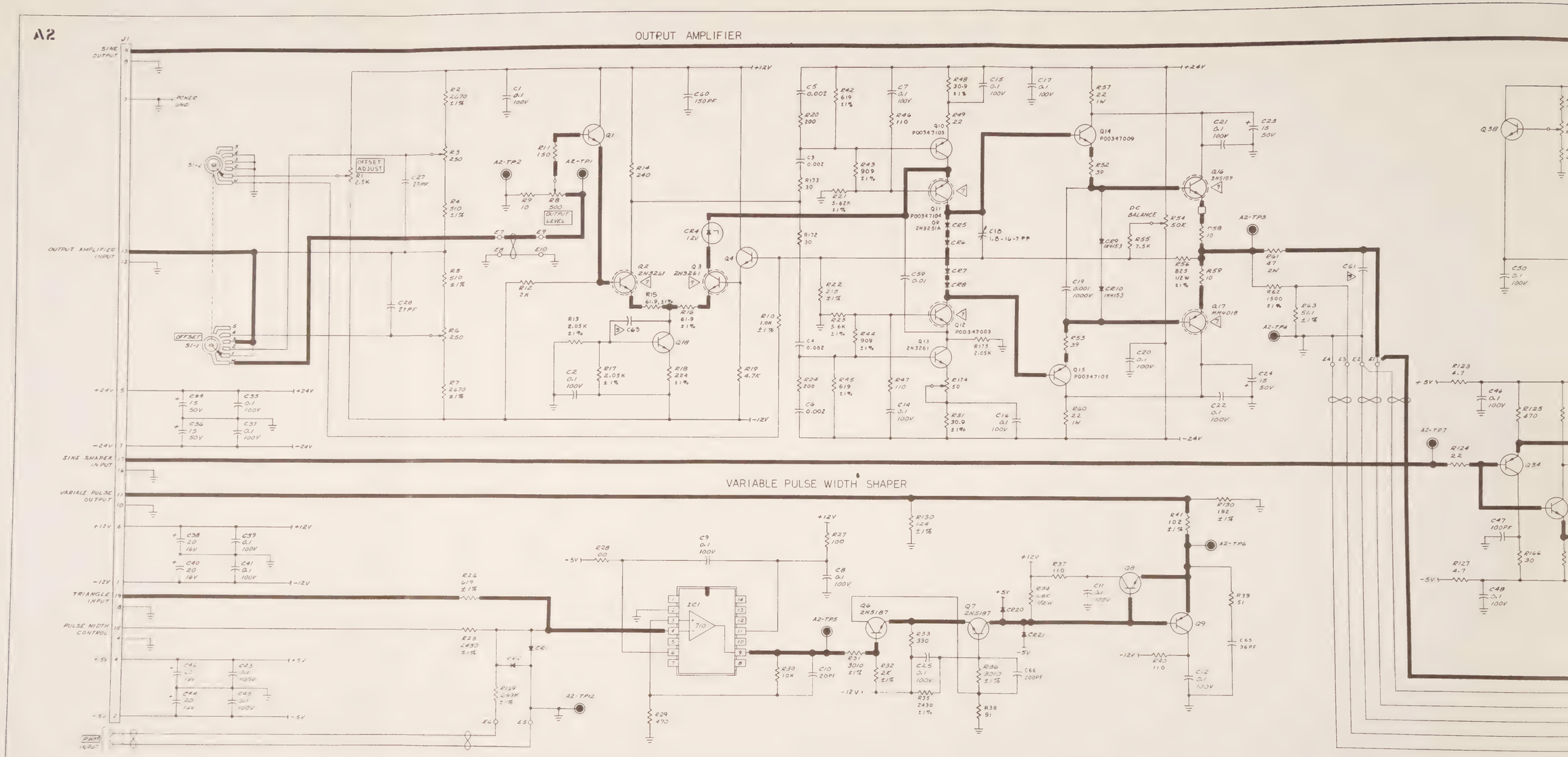


Figure 7-3. Main Board (A1) Schematic (Sheet 2 of 2 sheets)


A2
OUTPUT AMPLIFIER
VARIABLE PULSE WIDTH SHAPER
J1
SINE OUTPUT
POWER GND
OUTPUT AMPLIFIER INPUT
+24V
-24V
SINE SHAPER INPUT
VARIABLE PULSE OUTPUT
+12V
-12V
TRIANGLE INPUT
PULSE WIDTH CONTROL
+5V
-5V
PWM INPUT
OFFSET ADJUST R1 2.5K
OUTPUT LEVEL R8 500
DC BALANCE R54 50K
A2-TP1
A2-TP2
A2-TP3
A2-TP4
A2-TP5
A2-TP6
A2-TP7
A2-TP12
IC1
Q1
Q2 2N3261
Q3 2N3261
Q4
Q10 P00347103
Q11 P00347104
Q12 P00347003
Q13 2N3261
Q14 P00347009
Q15 P00347105
Q16 2N5189
Q17 MM4018
Q18
Q5 2N5187
Q6 2N5187
Q7 2N5187
Q8
Q9
Q34
Q38

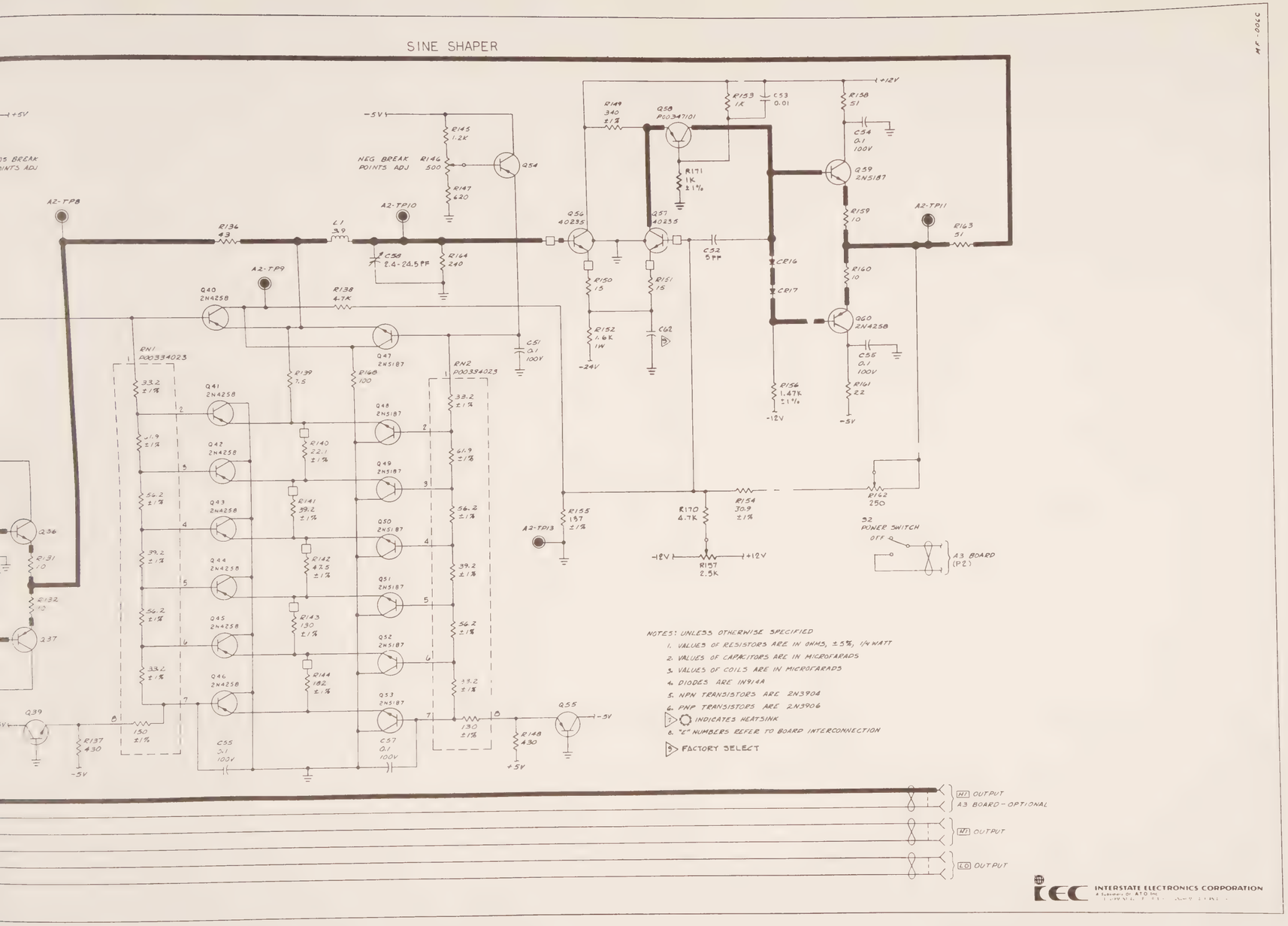


Figure 7-5. Auxiliary Board (A2) Schematic

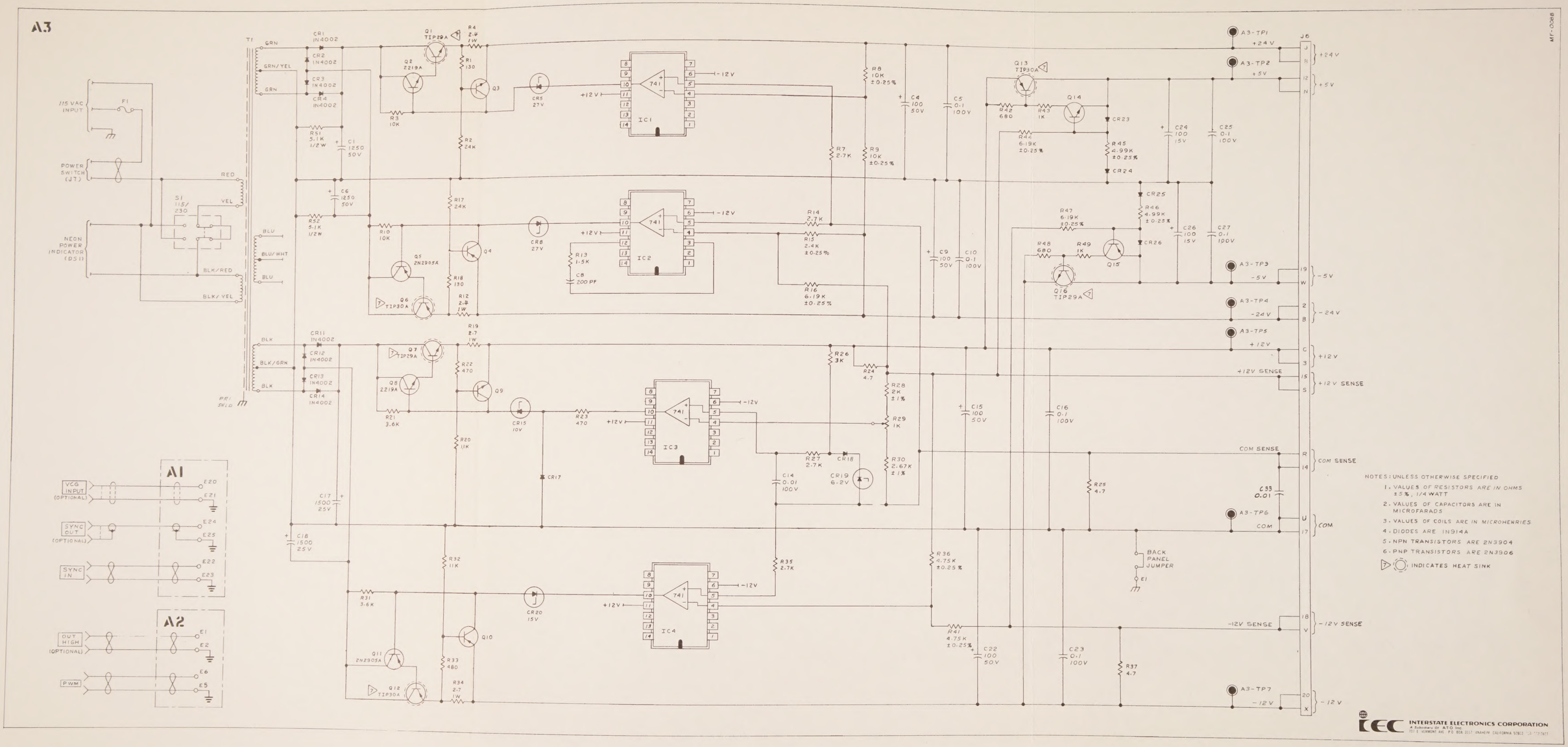


Figure 7-7. Power Supply Board (A3) Schematic